Nurturing ECSU Research Talent

1996-97

Annual Report

ONR . . . Investing in the Future
OFFICE OF 50 Anniversary NAVAL RESEARCH
1946 - 1996

SEIZING OPPORTUNITIES FOR ADVANCING RESEARCH SCHOLARS

This conference will bring together undergraduates to report research results from a wide range of disciplines, including the arts, humanities, social sciences, and natural sciences.

NORTH CAROLINA FALL CONFERENCE
ON UNDERGRADUATE RESEARCH

November 14-15, 1996
Elizabeth City State University

Conference Sponsor:
This conference is being sponsored and organized by the North Carolina Corsortium for Undergraduate Research (Elizabeth City State University, Fayetteville State University, North Carolina A&T State University, North Carolina Central University, Pembroke State University, The University of North Carolina at Asheville and Winston-Salem State University.)

Corporate Sponsor
GLAXO, INC.
Research Triangle Park, NC
Featured Speakers:
DR. LINDA BAILEY HAYDEN, Elizabeth City State University
DR. SLAYTON A. EVANS, JR., The University of North Carolina at Chapel Hill
DR. PAULINUS CHIGBU, Elizabeth City State University

DISTRIBUTION STATEMENT A
Approved for public release
Distribution Unlimited

National Association for Equal Opportunity in Higher Education (NAFEO)

1997 High Tech Expo Student Presentations

Focus

Georgia Tech **1996**

19970912 044

DTIC QUALITY INSPECTED 3

Elizabeth City State University

Elizabeth City, North Carolina

REPORT DOCUMENTATION PAGE

FORM APPROVED
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of the collection of information, including suggestions for reducing the burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302 and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
		Annual Report

4. TITLE AND SUBTITLE OF REPORT
Nurturing ECSU Research Talent Project
Research Program Yearbook

5. FUNDING NUMBERS
N00014-94-1-1089 PP and CV-1
N00014-94-1-0948 N-AASERT-2

6. AUTHOR(S)
Dr. Linda B. Hayden

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Elizabeth City State University
1704 Weeksville Road, Campus Box 672
Elizabeth City NC 27909

8. PERFORMING ORGANIZATION REPORT NUMBER:
5-52562
5-52561

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research

10. SPONSORING/MONITORING AGENCY REPORT NUMBER:

11. SUPPLEMENTARY NOTES:

12a. DISTRIBUTION AVAILABILITY STATEMENT
Unlimited

12b. DISTRIBUTION CODE
N00179

13. ABSTRACT (Maximum 200 words)

The attached 1996-97 Annual Report documents the Nurturing ECSU Research Talent Program: Research Team Reports, Mentors, GPA Data, Enrollment Data and Highlight Photos.

14. SUBJECT TERMS	15. NUMBER OF PAGES:
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT:	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

Table of Contents

DTIC QUALITY INSPECTED 8

This program, entitled "Nurturing ECSU Research Talent" focuses on undergraduate education and undergraduate research experiences. Nurturing these young researchers is our primary concern. Highest priority is given to providing them with the guidance and skills to insure their entrance and success in graduate school. Further, each student in our program learns the fundamentals of scientific research. Program activities are as follows:

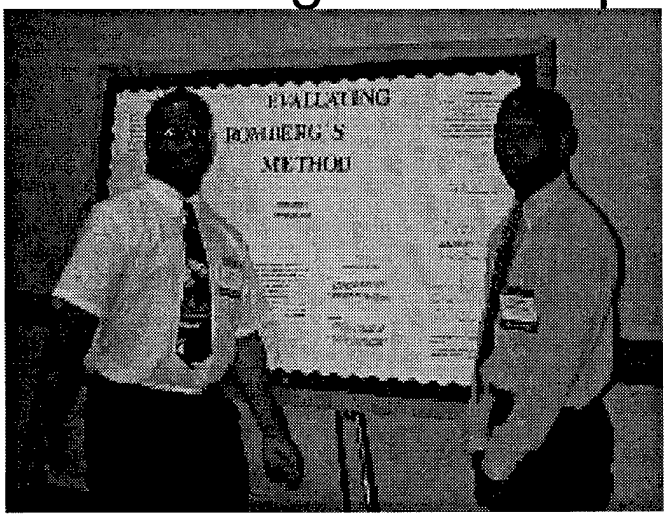
I. Student development activities:
   a) Recruitment of 5 high ability minority students each year.
   b) Providing a precollege/summer experience for recruited students.
   c) Providing research experiences;
   d) Providing a mentor, graduate school counseling and GRE preparation.
   e) Providing financial support for students in the form of research scholarships.
   f) Providing funds for student travel.

2. Infrastructure activities
   a) Enhancement of current computer graphics and operating systems courses.
   b) Development of a new course in computer visualization.
   c) Establishing a visiting lecture series in computer science.
   d) Hiring a UNIX network manager.
   e) Acquisition of computer equipment appropriate to support research training activities.

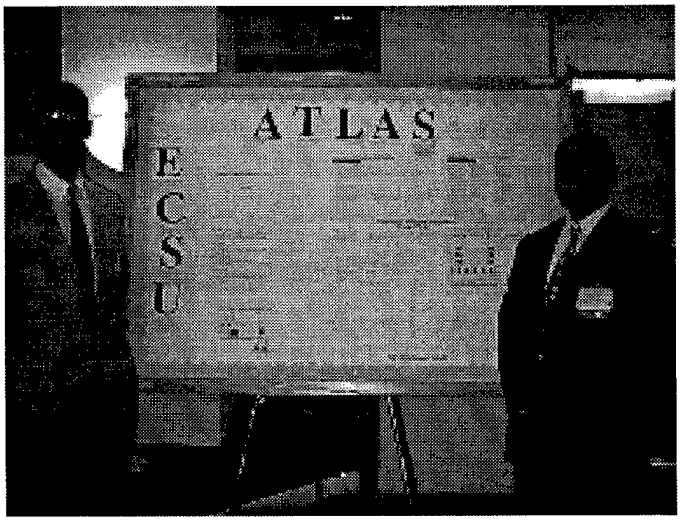
1996-97 Research Teams

Research Focus	Mentor	Team Members
Fractals/Chaos	Dr. D. Sengupta	Donald Charity, Fr/Math Corey Ellis, Jr/Applied Math Brian Jordan, Sr/Applied Math Ayonda Moore, Jr/Math Tammara Ward Jr/Math
Visualization	Dr. K. Edoh	Lakisha Mundon, So/Math Felica Bowser, Sr/CS Laverne Williams, Jr/CS
HTML/JAVA	Mrs. T. Chamberlain Dr. L. Hayden	Courtney Fields, So/CS Kuchumbi Hayden, So/CS Katrina Godwin, Fr/CS Shakiya Rodgers, Fr/CS
ATM Networks	Mr. D. Archer Dr. L. Hayden	Curtis Felton, Jr/CS Derrek Burrus, So/CS Antonio Rook, So/CS Fred Sessoms, Jr/CS Stacia McFadden, Sr/CS Charles Gatling, Jr/CS Melvin Anderson, Jr/CS Jamaal Turner, Jr/Ind Tech
Statistical Analysis	Dr. M. Mannan	Arthur Fenner, Jr/Math Tamara McCray, Jr/Math Toinette Jenkins, Fr/CS

NAFEO High Tech Expo



Brian Jordan and Arthur Fenner

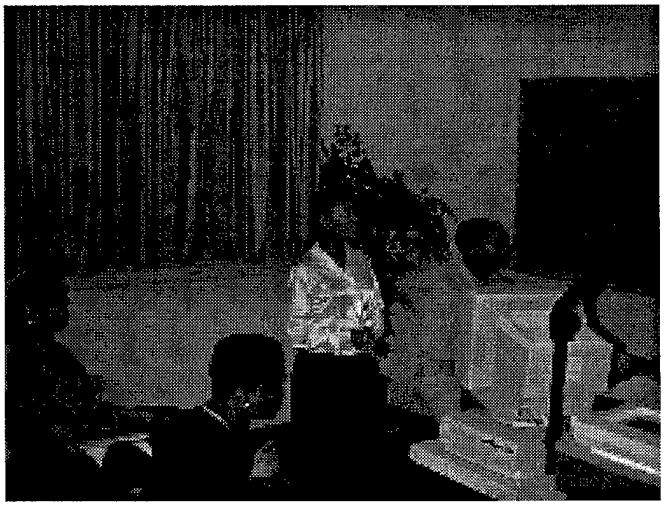


Curtis Felton and Derrek Burrus

Melvin Anderson and Lavern Williams

Highlights from the 1996-97 Research Program

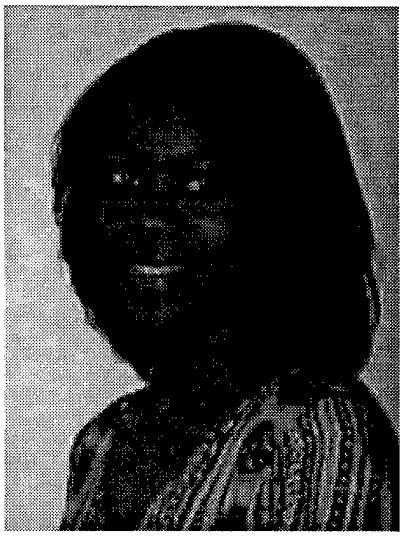
Donald Charity, Ayonda Moore and Lakisha Mundon (Fractals/Chaos)



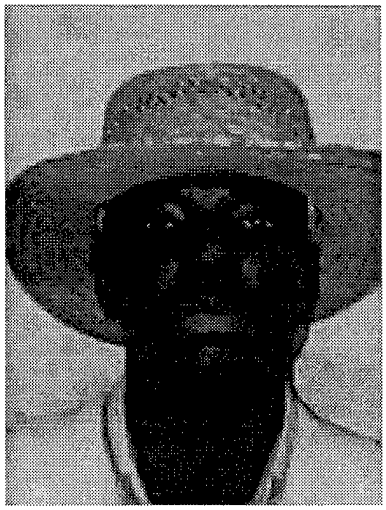
Shakiya Rodgers, Courtney Fields, Katrina Godwin & Kuchumbi Hayden (HTML/JAVA)

Highlights from the 1996-97 Research Program

Toinette Jenkins, Fr/CS



Tamara McCray, Jr/Math



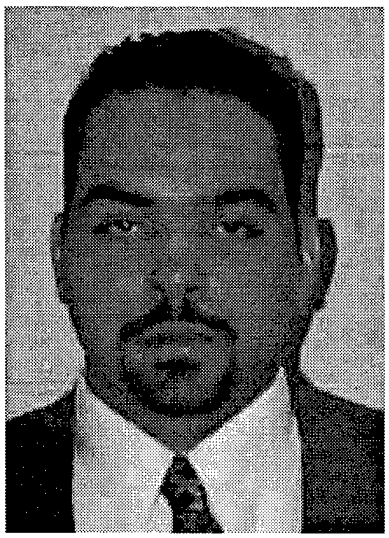
Melvin Anderson, Jr/CS

Lavern Williams, Jr/CS

Lakisha Mundon, So/Math

Katrina Godwin, Fr/CS

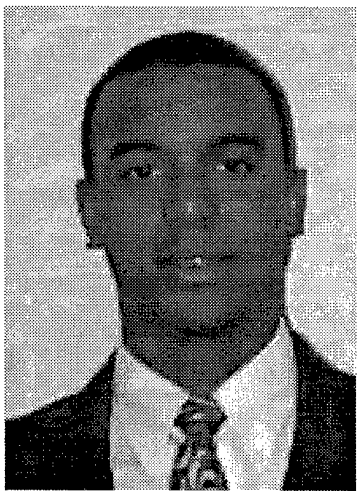
Jamal Turner, Jr/Tech



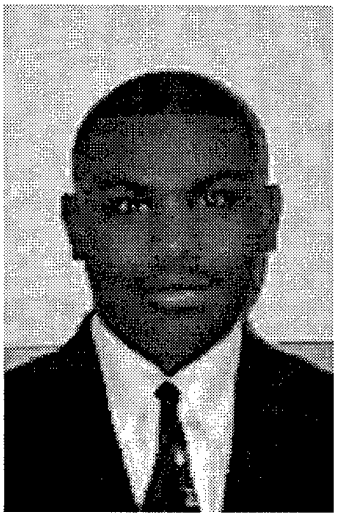
Fred Sessoms, Jr/CS

Felica Bowser, Sr/CS

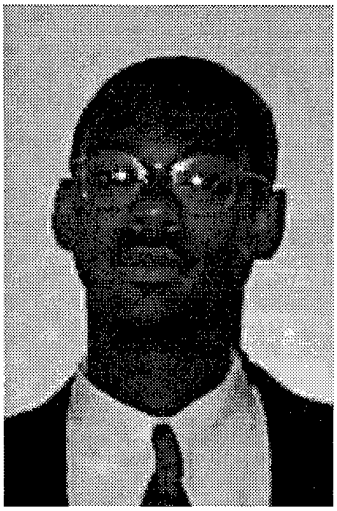
Highlights from the 1996-97 Research Program



Donald Charity Fr/Math

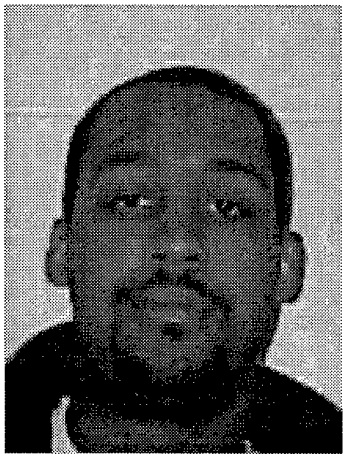


Derrek Burrus, So/CS

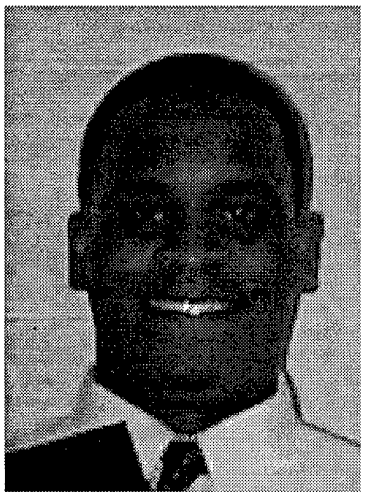


Curtis Felton, Jr/CS

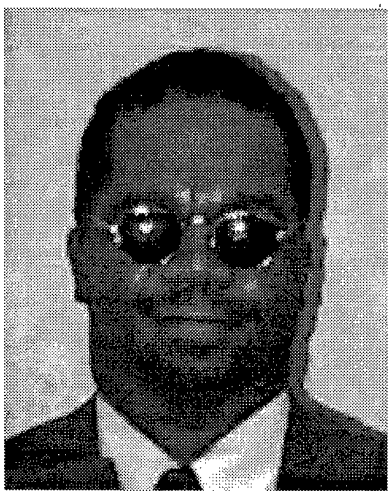
Courtney Fields, So/CS



Corey Fields, Jr/Math



Charles Gatling, Jr/CS

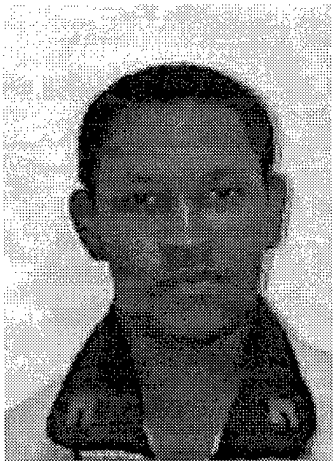


Brian Jordan, Sr/Math

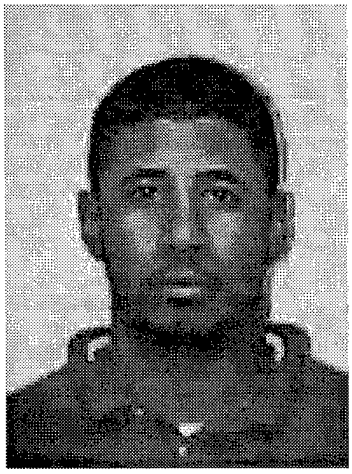
Arther Fenner, Jr/Math

Ayonda Moore, Jr/Math

Highlights from the 1996-97 Research Program



Kuchumbi Hayden, So/CS

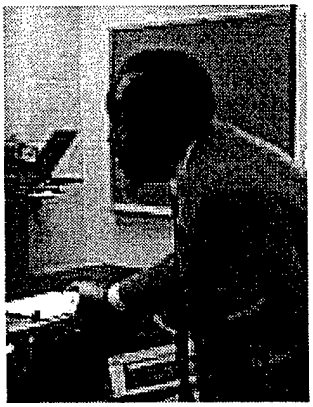


Antonio Rook, So/CS

Shakiya Rodgers, Fr/CS

Stacia McFadden Sr/CS

Umfort Locus Lecture Hall and Reception Center
Dedication Service

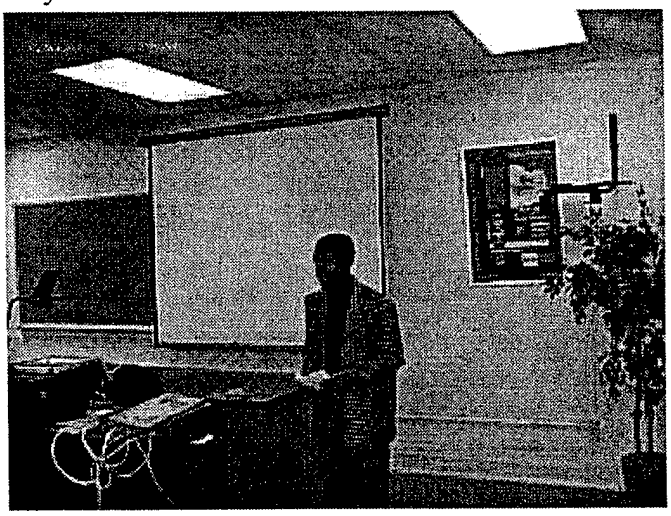


Dr. James Donaldson, Professor
Howard University

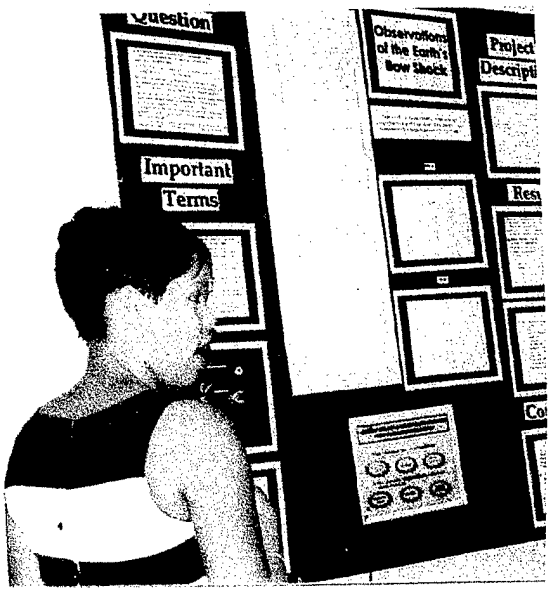
Dr. Mickey Burnim, Mrs. Delmo Locus, Umfort Locus III
Dr. Helen Caldwell, Dr. Sohindar Sachdev, Dr. Johnny
Houston, Dr. Linda Hayden, Mrs. Locus (seated)

Feb. 4, 1997

Wayman White and Felica Bowser
Past Umfort Locus Award Winners

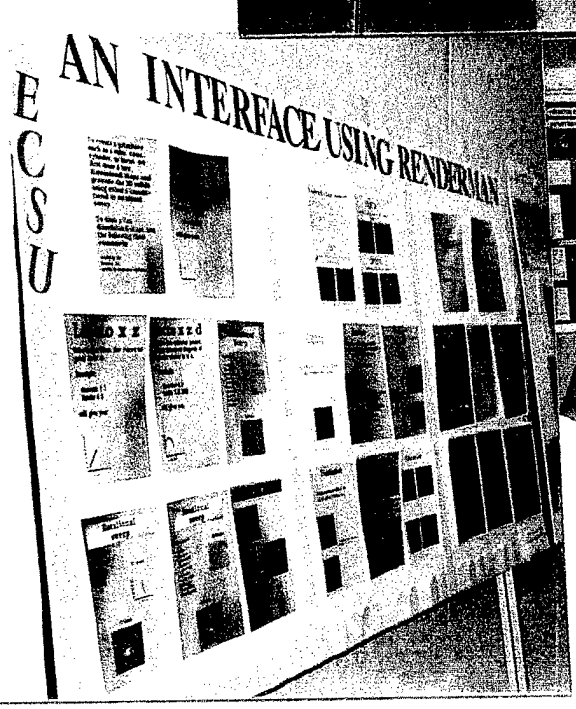


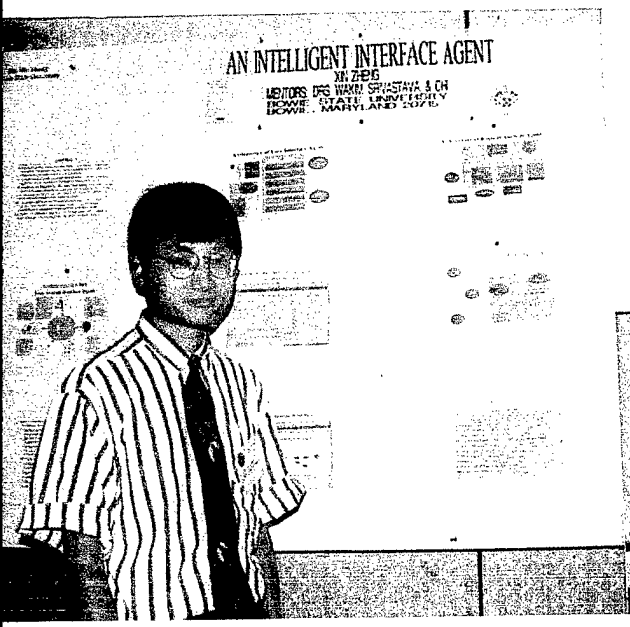
Rev. Wilkens, Academic Computing Center
Manager and past student of Umfort Locus Jr.

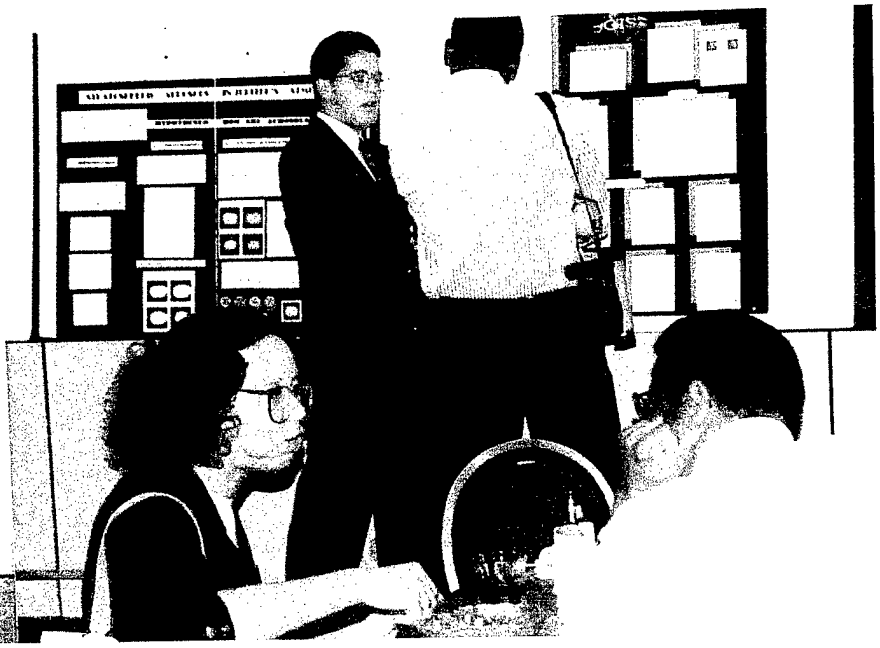


MUSPIN Conference
El Paso, Tx


VIRTUALLY USING
LESTER HALL
VIRTUS VR


AN INTERFACE USING RENDERMAN
ECSU

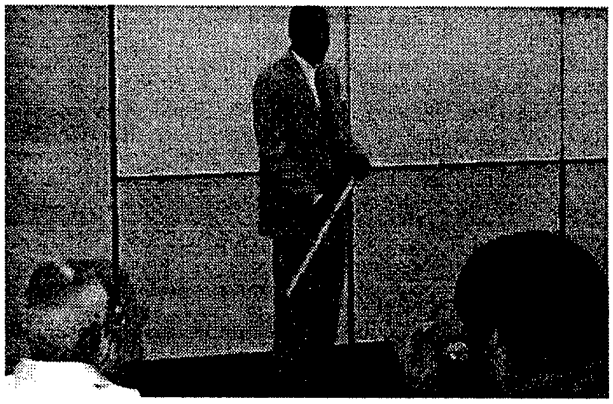

AN INTELLIGENT INTERFACE AGENT

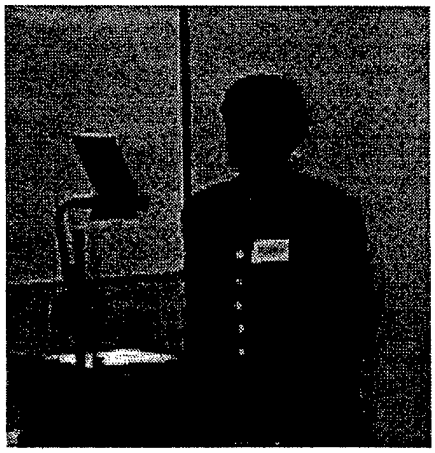


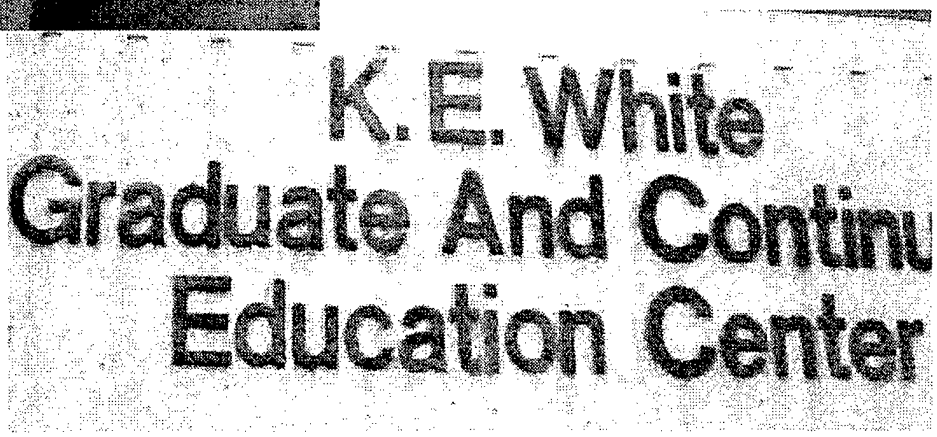
ADMJ Conference
Mayaguez, Puerto Rico

ADMJ Conference
Mayaguez, Puerto Rico

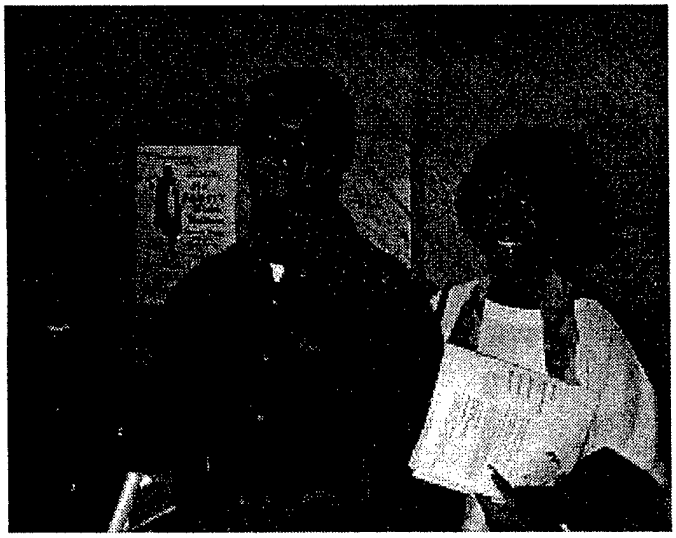
SOARS 1997

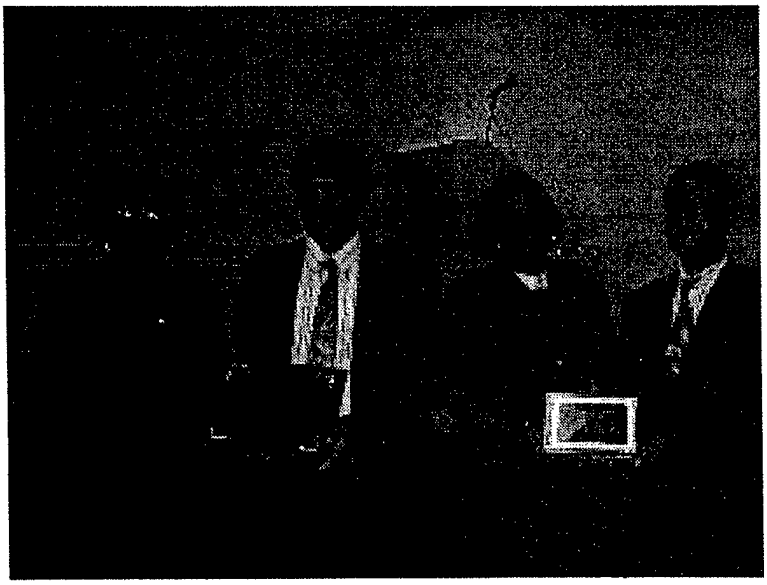






SOARS 1997





	Summer 1997 Internship Application Report		
Student Researcher	**class**	**Internship/Summer Study**	**accepted or pending**
Anderson, Melvin	jr	ITS	Accepted
Bowser, Felicia	sr	Langley Research Center - LARSS	Accepted
Burrus, Derrek	so	Educational Data Systems- Raleigh	Accepted
Charity, Donald	fr	FERMILAB	Pending
Ellis, Corey	jr	Langley Research Center - LARSS	Accepted
Felton, Curtis	jr	Georgia Institute of Technology	Accepted
Fenner, Arthur	jr	Argonne Lab	Pending
Fields, Courtney	so	Ronald McNair Program	Accepted
Gatling, Charles	jr	Naval Research Lab	Accepted
Godwin, Katrina	fr	NAFEO Internship Program	Accepted
Hayden, Kuchumbi	so	Ronald McNair Program-Trainer	Accepted
Jenkins, Toinette	fr	Department of Energy	Pending
Jordan, Brian	sr	Goddard Space Flight Center Internship	Accepted
McFadden, Stacia	sr	GEM Fellowship - Timken Corp.	Accepted
McCray, Tamara	jr	Ronald McNair Program	Accepted
Moore, Ayonda	jr	Ronald McNair Program	Accepted
Mundon, Lakisha	so	Ronald McNair Program	Accepted
Rodgers, Shakiya	fr	Department of Energy	Pending
Rook, Antonio	so	Albermarle Hospital	Accepted
Sessoms, Fred	jr	IBM	Accepted
Turner, Jamaal	jr	Ronald McNair Program	Accepted
Turner, Reginal	sr	Webmaster - NASA NRTS	Accepted
Williams, Laverne	jr	FERMILAB	Accepted
Ward, Tammara	jr	SERS	Completed

1996-97 Enrollment and GPA Report

Major Discipline	Number of students enrolled at school (by year)				Number of students enrolled in ONR (by year)				Number of students graduated		Number Graduate Professional School	
	FR	SO	JR	SR	FR	SO	JR	SR	total	ONR	total	ONR
Engineering	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Biology	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chemistry	9	5	3	3	0	0	0	0	4	0	0	0
Computer Science	58	39	29	25	2	4	1	3	18	4	0	3
Mathematics	8	5	13	18	1	1	2	2	13	1	0	1
Physics	1	1	0	1	0	0	0	0	1	0	0	0
Totals	76	48	47	47	3	5	3	5	36	5	0	4

Class Year	Mean GPA for all Students	Mean GPA for ONR Students
Freshman	2.3026	3.5180
Sophomore	2.2967	3.1022
Junior	2.7257	3.5000
Senior	2.9360	3.5678

Elizabeth City State University

ELIZABETH CITY, NORTH CAROLINA

MICKEY L. BURNIM, CHANCELLOR

Honors Convocation

Thursday, April 17, 1997
2:00 o'clock in the afternoon
Moore Hall Auditorium

Elizabeth City State University is a constituent institution of
THE UNIVERSITY OF NORTH CAROLINA

PRELUDE ..... *"Adagio in g minor"* ..... Tomaso Albinoni
Dr. Rachel W. Gragson, *Organist*

Program

Dr. Helen M. Caldwell, *Vice Chancellor for Academic Affairs*
- Presiding -

INVOCATION ..... The Reverend Derrick Wilkins
Manager, ECSU Academic Computing Center
Graduate, Honors Program

MUSICAL SELECTION ..... *"All The Earth Sing Unto The Lord"* ..... Lena McLin
The University Choir
Mr. Billy Hines, *Conductor*

INTRODUCTION OF SPEAKER ..... Miss Laverne Williams
Junior, Honors Program

ADDRESS ..... Dr. Freddye T. Davy
Director of the Honors College
Hampton University, Hampton, Virginia

PRESENTATION OF AWARDS ..... Dr. Rachel W. Gragson
Chairman, Honors Council
Dr. Carol C. Jones
Director, Honors Program
Miss Dana Wood
Senior, Honors Program

CONGRATULATIONS ..... Dr. Mickey L. Burnim
Chancellor

ANNOUNCEMENTS ..... Miss Trina Payne
Senior, Honors Program

POSTLUDE ..... *"Chorale and Allegro"* ..... Ludwig Boellmann
Dr. Rachel W. Gragson, *Organist*

Special Honors Awards

Certificates Presented by the Honors Program - Awarded to all Students for Spring Semester, 1995-96 and Fall Semester 1996-97 (as listed)

CHANCELLOR'S DISTINGUISHED EMBLEM AWARDS

Scholar's Blazers

Carmen Bolden
Tamara Lewis
Benjamin Roberts, Jr.
Beatrice Shearn

THE HONORS PROGRAM

Certificates of Merit

Karen Backus
Stacey Baker
Chenay Beamon
Felicia Best
Bonita Boone
Loukisha Boyd
Andrae Brown
Samantha Brown
Shelia Bryson
Derrek Burrus
Tanisha Cowell
Stephanie Dance
Tarsha Darden
Sharmel Edwards
Corey Ellis
Keywonna Everette
Judith Fields
Steven Gilchrist
Tamara Hedgebeth
Nicole Hoffler
Crystal Keyes
Karlton Lane
Harold Lawson, Jr.
Stacia McFadden
Terrica Nelson
Synetheia Newby
Jennifer Nooney
Trina Payne
Natasha Peters
Phillip Puryear
Alisha Reid
Jason Riddick
Felicia Saunders
Fredrika Simons
Tabetha Summerlin
Angel Swimme
Kenyatta Thomas
Jarrod Turner
Ahmad Ward
Laverne Williams
Dana Wood

HONORS PROGRAM DARIN L. COLE AWARD ..... Samantha Brown Keywonna Everette Tamara Hedgebeth Fredrika Simons Angel Swimme Kenyatta Thomas Laverne Williams

GREEK HONORS CUP ..... Delta Chi Chapter
Delta Sigma Theta Sorority, Inc.

BIOLOGY DEPARTMENT

Clarence E. Biggs Award ..... Sonya Longest
Evans/Patterson Science Award ..... Sonya Longest
Herman Cooke Research Excellence Award ..... Steven Gilchrist
Curtis D. Turnage Award ..... Karen Oakley
Freshman Achievement Award in Biology ..... Bettina Holloman Kimberly Knight
Sophomore Achievement Award in Biology ..... Scott Forbes

BUSINESS AND ECONOMICS DEPARTMENT

Graduating Senior Award ..... Allie Gladden
Junior Award ..... Rachelle Holmes
Excellence In Accounting Award ..... Ruth Thomas
Excellence In Business Education Award ..... Amy Disbennet
Excellence In Economics & Finance Award ..... Angela Sneed
Excellence in Management Award ..... Timothy White
Excellence in Marketing Award ..... Dana Wood
Excellence in Accounting Education Award ..... Willie Moore
Wachovia Fund for Excellence Award ..... Angela Sneed Angela Jennings
Professional Excellence Award - NABA Chapter ..... Chelsea Rayner
Professional Excellence Award - Phi Beta Lambda ..... Michelle Lane
Professional Excellence Award - SIFE ..... Brandon Scott
Becker CPA Scholarship ..... James McClellan

DIVISION OF EDUCATION

James & Elizabeth Cofield Award ..... Garrett Taylor Tikisha Joyner Stacey Baker
Charles A. Bryant Scholarship ..... Crystal Godfrey
Lois W. Green Graduating Senior Award in Teacher Education ..... Judith Fields
Outstanding Senior in Psychology Award ..... Diane Han
Outstanding Junior in Psychology Award ..... Natasha Peters
Outstanding Sophomore in Psychology Award ..... Jarrod Turner
Outstanding Psi Chi Graduate ..... Tracia Rountree
Elementary Education Outstanding Academic Performance Award ..... Stacey Baker Judith Fields Syvillia Futrell Brenda Nash

EDUCATIONAL TALENT SEARCH PROGRAM

Academic Excellence Award ..... Rocky Allen Nicole Woodard
Exemplary Service Award ..... Darrick Banks Naomi Pittman Keith Robinson
McNair Scholars Eagle Award ..... Melvin Anderson Courtney Fields Talesh Lane Tamara McCray Lakishia Mundon Chengee White
McNair Scholars Challenger Award ..... Charles Gatling Sonya Longest Jamaal Turner
McNair Scholars Excellence Without Excuse Award ..... Felicia Bowser Warren Judge Karen Oakley Laverne Williams

GENERAL STUDIES DIVISION

Division of General Studies Award ..... Lakisha Basnight

GEOSCIENCES DEPARTMENT

Freshman/Sophomore Academic Award ..... Andre' Dean
Senior Academic Award ..... Sunday Tinnell

INCENTIVE SCHOLARSHIP PROGRAM

Outstanding Freshman Incentive Scholar ..... Bettina Holloman
Outstanding Sophomore Incentive Scholar ..... Scott Forbes, Jr.
Outstanding Junior Incentive Scholar ..... Angel Swimme
Outstanding Senior Incentive Scholar ..... Felicia Bowser

LANGUAGE, LITERATURE & COMMUNICATION DEPARTMENT

Graduating Senior Award ..... Phillip Puryear
E. M. Spellman Award ..... YuShawnda Thomas

MATHEMATICS & COMPUTER SCIENCE DEPARTMENT

The S. S. Sachdev Senior Award in Mathematics ..... Brian Jordan
The J. L. Houston Senior Award in Computer Science ..... Stacia McFadden Felicia Bowser
The Umfort E. Locus Sophomore Award in Computer Science ..... Nicole Hoffler
The Margaret G. Sharpe Award ..... Jennifer Felton
NASA-NRTS Service and Achievement Award ..... Katrina Godwin Kimberly Wright Tamara McCray Fred Sessoms Shanita Powell Kuchumbi Hayden Courtney Fields
ONR- Nurturing ECSU Research Program Award ..... Donald Charity Katrina Godwin Toinette Jenkins Kuchumbi Hayden Tamara McCray Tammara Ward

Office of Naval Research Scholars Award ..... Melvin Anderson Derrek Burrus Curtis Felton
Courtney Fields Laverne Williams Jamaal Turner
Lakisha Mundon Fred Sessoms Felicia Bowser
Corey Ellis Arthur Fenner Charles Gatling
Brian Jordan Ayonda Moore Antonio Rook

Office of Naval Research Award of Excellence ..... Stacia McFadden

MUSIC DEPARTMENT

Music Department Award ..... Delicia Wright
Edna Davis Theory Award ..... Brian Snow
Florence Folkes Lassiter Award ..... Toneika Stephens

PHYSICAL SCIENCES DEPARTMENT

1997 Outstanding Student Chemist Award ..... Angelina Brown
Rochelle Cleaners Excellence in Chemistry Award ..... Angelina Brown
Physical Sciences Achievement Award ..... Angelina Brown Santiel Creekmore
Craig Foster Melinda Lee Mark Mwaura
Veronica Overton Nadirah Shaw Alethea Swan
Charles Taft, Jr. Timeka Whitehead Scottie Williams

SOCIAL SCIENCES DEPARTMENT

Department of Social Sciences Award ..... Carmen Bolden
Timothy H. Wamack Scholarship ..... Kenya Morris
Butts/Simpson Scholarship ..... Beatrice Shearn
History Excellence Award ..... Lee Robinson Virginia Parker
Political Science Academic Excellence Award ..... William Scott
Criminal Justice Excellence Award ..... Carmen Bolden Melissa Ferrell Beatrice Shearn
Sheila Gordon Synetheia Newby Andre Howell
Social Work Excellence Award ..... Cherie Morris Tracie Owens
Sociology Excellence Award ..... Cheryl Tate

STUDENT AFFAIRS DIVISION

Davis Cup ..... New Complex
Accepting - Felicia Best
Honda Campus All-Star Challenge Team ..... Harold Lawson, Jr. James Martin, III
Shaunell McMillan Phillip Puryear Ahmad Ward
Henrietta B. Ridley Excellence in Leadership Award for 1996 ..... Antonio Porch
Henrietta B. Ridley Excellence in Leadership Award for 1997 ..... Tamara McCray

STUDENT SUPPORT SERVICES AWARD ..... Bettina Holloman

TECHNOLOGY DEPARTMENT

Freshman Achievement Award in Technology ..... Travis Evans
Sophomore Achievement Award in Technology ..... Barron Neal
Junior Achievement Award in Technology ..... Jamaal Turner
Industrial Technology Faculty Award ..... Benjamin Roberts

CLUBS AND ORGANIZATIONAL AWARDS

The Alpha Kappa Alpha Sorority Scholarship
Zeta Kappa Omega Chapter ..... Tamara Hedgebeth
The Delta Sigma Theta Sorority Scholarship
Elizabeth City Alumnae Chapter ..... Samantha Brown

WHO'S WHO

Travis Albritton
Karen Backus
Felicia Bowser ✓
Loukisha Boyd
Caprissa Brown
Samantha Brown ✓
Angela Burrus
Zellene Cochran
Keywonna Everette
Curtis Felton ✓
Judith Fields
Elouise Francis
Charles Gatling ✓
Julie Gregory
Wendy Gurganus
Tamara Hedgebeth
Christopher Johnson
Warren Judge
Lena Kee
Karlton Lane
Karen Lowe
Shayne Martin
Willie Moore
Cherie Morris
Tiffany Newell
Pamela Owens
Jason Pearce
Allison Pendleton
Natasha Peters
Amy Priest
Phillip Puryear
Alisha Reid
Benjamin Roberts, Jr.
Francis Sakala
Joyce Shaw
Beatrice Shearn
Fredrika Simons
Priscilla Smith
Samantha Smith
Brian Snow
Angel Swimme
Kenyatta Thomas
Corey Tyler
Ahmad Ward
Gary Whidbee
Debbie Wilkins
Laverne Williams ✓
Delicia Wright

Chancellor's Distinguished Emblem Award
Spring Semester 1995-96

Kimberly D. Ambrose
Pamela M. Armstrong
Tynoshia D. Barnes
Chenay Beamon
Crystal L. Belfield
Tiffany R. Belfield
Kelvin A. Black
Tonya D. Blair
Carmen T. Bolden
Felica A. Bowser
Tonya M. Brinkley
Lisa C. Chappell
Thomas H. Clifton
Jennifer L. Collins
Tarsha J. Darden
Kesha D. Dukes
Latisha O. Edwards
Trenace N. Fayton
Jennifer F. Felton
Karen A. Fennell
Judith L. Fields
Shawnetta D. Fleming
Scott L. Forbes
Uwezo B. Frazier
Charles L. Gatling ✓
Shawn T. Glasper
Susan M. Goodwin
Kimbala S. Goss
Euless M. Hall
Makesha S. Hinton
Susan M. Hodge
Rachel A. Holmes
Kendric A. Jacson
Louise Jefferson
Christopher K. Johnson
Kristie R. Jordan
April D. Keeter
Keisha M. Kent
Tiesha S. Kirkland
Tanya J. Kuno
Tamara T. Lewis
Sonya B. Longest
Dessalines M. McClure
Stacia L. McFadden ✓
Louis T. Meads

Ayonda D. Moore ✓
Corina R. Morris
Julia A. Motta
Anjanette D. Murphy
Synetheia N. Newby
Katrina M. Nixon
Karen A. Oakley
Trina Y. Payne
Deborah D. Phillips
Sypress J. Preston
Phillip E. Puryear
Tabitha L. Rice
Benjamin G. Roberts, Jr.
Jenny L. Roffo
Jean A. Samuel
Elizabeth B. Sawyer
Summer L. Sayers
Beatrice K. Shearn
Rachael M. Silverwood
Simona L. Simons
Tina D. Slone
Samantha G. Smith
Torie Y. Smith
Erle S. Solesbee
Teia S. Stephenson
Angel P. Swimme
Nakeisha S. Sylver
Charles J. Taft, Jr.
Kenyatta M. Thomas
Corey R. Tyler
Tamika C. Wallace
Kimberly R. Walston
Rebecca L. Walston
Betty T. Waters
Jorice J. Webb
Kimberly A. White
Roslyn R. White
Jenee E. Williams
Laverne S. Williams ✓
Melissa Williams
Raymond A. Williams
Angie L. Winfree
Dana L. Wood
Toni L. Wood

Chancellor's Distinguished Emblem Award
Fall Semester 1996-97

Rocky L. Allen
Karen D. Backus
Valerie W. Banks
Lakisha S. Basnight
Chenay Beamon
Theo N. Bohn
Carmen T. Bolden
Felica A. Bowser ✓
Tammy B. Bray
Tonya M. Brinkley
Nicholas T. Britt
Craig A. Byers
Miles C. Daniels
Tarsha J. Darden
Mark A. Delosreyes
Sharmel D. Edwards
Jo Ann Eiler
Marita C. Elliott
Larry C. Elmore
Jennifer F. Felton
Judith L. Fields
Scott L. Forbes
Monte T. Freeman
Freda J. Garland
Steven L. Gilchrist
Katrina Y. Godwin ✓
Tamara L. Hedgebeth
Bettina S. Holloman
Rachel A. Holmes
Frances E. Hughes
Sadie B. Jernigan
Christopher K. Johnson
Bessie C. Jones
Kristie R. Jordan
Jennie B. King
Kimberly N. Knight
Joseph Kurtzweil
Harold V. Lawson, Jr.
Sonya B. Longest
Ralisha M. Mercer
Stacia L. McFadden ✓
Julie A. Motta
Mark M. Mwaura
Anna W. O'Brien
Virginia G. Parker
Kenneth E. Perry
Karen A. Oakley
Veronica R. Overton
Tracie R. Owens
Trina Y. Payne
Phillip E. Puryear
Benjamin G. Roberts, Jr.
Summer L. Sayers
Beatrice K. Shearn
Casandra L. Smith
Bonnie W. Stroud
Angel P. Swimme
Byron D. Thigpen
Annette K. Tiller
Jamaal Turner ✓
Porchia L. Unthank
Bryan N. Walke
Tamika C. Wallace
Betty T. Waters
Debbie L. Watson
Gary D. Whidbee
Laverne S. Williams ✓
Angie L. Winfree
Delicia A. Wright

Honors Spring Semester 1995-96

Chancellor's List: 3.75 to 4.0 Average

Kimberly D. Ambrose
Pamela M. Armstrong
Marsha T. Bacenko
Tynoshia O. Barnes
Lee G. Barnhart
Tammi Bass
Chenay Beamon
Crystal L. Belfield
Tiffany R. Belfield
Donna H. Bembridge
Kelvin A. Black
Tonya D. Blair
Carmen T. Bolden
Marsha G. Boniface
Felicia A. Bowser
Russell L. Boyd
Tonya M. Brinkley
Meredith L. Capraro
Marja-Leena Casey
Samuel D. Chambers
Lisa C. Chappell
Cheryl L. Cherry
Thomas H. Clifton
Zellene S. Cochran
Adam M. Collins
Jennifer L. Collins
Louise I. Croswait
Karl B. Dail
Tarsha J. Darden
Kimberly J. Denby
Kesha D. Dukes
Debra L. Eason
Brenda O. Edwards
Latisha O. Edwards
Trenace N. Fayton
Jennifer F. Felton
Karen A. Fennell
Melissa J. Ferrell
Judith L. Fields
Shawnetta D. Fleming
Scott L. Forbes
Uwezo B. Frazier
Charles L. Gatling
Donna P. Gilbird
Allie B. Gladden
Shawn T. Glasper
Deborah B. Goodman
Ann H. Goodwin
Susan M. Goodwin
Shelia P. Gordon
Kimbala S. Goss
Karen A. Griffin
Lorene R. Grunwald
Rachel Marie S. Haines
Euless M. Hall
Diane M. Han
James W. Hardy
Katherine B. Harrison
Jacqueline R. Head
Makesha S. Hinton
Susan M. Hodge
Ruby M. Holder
Rachel Ann Holmes
James M. Hunsinger
Kendric A. Jackson
Louise Jefferson
Angela M. Jennings
James W. Jernigan, Jr.
Christopher K. Johnson
Lisa M. Johnson
William D. Johnson
Meri L. Jolin
Heather W. Jones
Kristie R. Jordan
Warren D. Judge
Joelle M. Karout
April D. Keeter
Robert H. Kelley
Keisha M. Kent
Mary K. Kincaid
Rebecca U. Kirkbride
Tiesha S. Kirkland
George F. Koch, III
Lynn A. Kotzlan
Tanya J. Kuno
Michelle M. La Hair
Sharon R. Lanneau
Elaina M. Lawson
Linda S. Lenau
Nathan A. Leonard
Tamara T. Lewis
Dennis E. Linney
Sonya B. Longest
Karen B. Lowe
Deanna L. Marshall
Christi T. Martin
Shayne Martin
Dessalines M. McClure
Stacia L. McFadden
Michael J. McMahon
Louis T. Meads
Cherrie A. Meredith
Jeffrey E. Mesowski
Paula W. Mickey
Tracy S. Mitchell
Ayonda D. Moore
Corina R. Morris
Julie A. Motta
Michael Munoz
Anjanette D. Murphy
Rebecca L. Myers
Lynn E. Needham
Synetheia N. Newby
Judith A. Newsome
Katrina M. Nixon
Crystal Norton
Karen A. Oakley
Mary C. Owen
Trina Y. Payne
Valerie T. Peterson
Deborah D. Phillips
Sypress J. Preston
Robert W. Privott
Jennifer S. Pugh
Dondrea M. Purnell
Phillip E. Puryear
Tabitha L. Rice
Benjamin G. Roberts, Jr.
Lee T. Robinson
Mary J. Rodgers
Jenny L. Roffo
Amy J. Ross
Gladys H. Russell
Jean A. Samuel
Elizabeth B. Saywer
Summer L. Sayers
Aleetalynn H. Schenesky
Charlotte A. Schoen
Cliff R. Schweitzer
Wiliam E. Scott, Jr.
Shawn T. Sewell
Harriet H. Shannon
Beatrice K. Shearn
Simona L. Simons
Paula J. Simpson
Tina D. Slone
Samantha G. Smith
Torie Y. Smith
Erie S. Solesbee
Katherine G. Soria
Ann D. Spivey
Robin T. Stallings
Anita G. Staples
Teia S. Stephenson
Gene A. Stovall
Sandy D. Stroberg
April M. Swift
Angel P. Swimme
Nakeisha S. Sylver
Charles J. Taft, Jr
Cheryl L. Tate
Albert L. Thomas
Kenyatta M. Thomas
Ruth D. Thomas
Neema G. Tillery
Sunday K. Tinnell
Corey R. Tyler
Tamika C. Wallace
Kimberly R. Walston
Rebecca L. Walston
Trisha D. Walton
Betty T. Waters
Jorice J. Webb
Cheryl D. Welch
Diane C. Whedbee
Kimberly A. White
Leanora W. M. White
Melissa W. White
Roslyn R. White
Kenya L. Whittington
Jenee E. Williams
Laverne S. Williams
Melvin L. Williams, Jr.
Raymond A. Williams
Angie L. Winfree
Dana L. Wood
Toni L. Wood

Vice-Chancellor's List: 3.50 to 3.74 Average

Floyd C. Adams
Travis J. Albritton
Kewanna F. Alexander
Virginia L. Ambrose
Diane E. Andersen
Stacey L. Baker
Amy C. Banks
Anjanette R. Barnes
Crystal L. Barnes
Marcy L. Bergman
Heather L. Biggs
Demitrous R. Blount
Dawn M. Boncek
Irma H. Bonner
Bonita L. Boone
Kimberly S. Booth
Kimberly D. Brothers
Caprissa S. Brown
Kimberly R. Bunch
Lekesha D. Burge
Bobby Burrus
Tarsha R. Calhoon
Jackie B. Cameron
Jennifer L. Capps
Pamela W. Chamblee
Annette E. Cherry
Melissa W. Colombo
Miles C. Daniels
Amy Dawn Disbennett
Tynisha Dorsey
Edward L. Dula
Tonya N. Eason
Cheryl D. Eatmon
Sharmel D. Edwards
Michelle M. Ellinwood
Curtis W. Felton
Janet R. Ferrell
Michael G. Fields
Coletta R. Fleming
Elouise Francis
John C. Gambrell
Chonda S. Gayle
James C. Gibbons
Robert C. Golden
Crystal D. Goodwin
Mary C. Griffin
Wendy S. Gurganus
Lynette M. Hall
Marlon D. Hall
Keisha Harrell
Barbara D. Hines
Nicole M. Hoffler
Zabrina Y. Hoggard
Sonya L. Holley
Jermone L. Holloman
Melvin C. Hooker
Andre T. Howell
Stephanie C. Johnston
Hope Y. Jones
Sheretta L. Jones
Tara L. Jones
Lena L. Kee
Gary W. Kehner
Ray V. Keyes, Jr.
Tracey E. Kinsey
Vickie L. Lambert
Karlton L. Lane
Carole B. Lawrence
Norma G. Lawson
Carol A. Lewis
Jenee M. Lewis
Forrest W. Liverman
Jamie C. Liverman
William E. Luton
Adam L. McGough
Bryan I. Mitchell
Juanita T. Mitchell
Mario O. Moore
Willie D. Moore
Cherie A. Morris
Lakisha D. Mundon
Mark M. Mwaura
Tracy L. Nixon
Lebechi A. Njoku
Linda A. Njoku
Andre C. Norwood
Thanh V. On
Tracie R. Owens
Lillie B. Pailin
Jason C. Pearce
Judy E. Peirson
Priscilla Perry
Keynisha D. Powell
Nakia K. Pride
Eric B. Quidley
Tamara D. Rainey
Alisha M. Reid
Brandi Richardson
Jason M. Riddick
Latonia S. Riddick
Courtney E. Robinson
Nicole M. Robinson
Marcenda J. Rogers
Francis S. Sakala
Bonnie S. Scarborough
Crystal W. Schultz
Daniel L. Smith
Stacy M. Smith
Fennessa L. Spruill
Loryn M. Stevens
Taburica R. Stewart
Debbie K. Strawhand
Bonnie W. Stroud
Jannifer H. Sykes
Varick T. Taylor
Edwana N. Thompson
Jamaal Truner
Jarrod W. Turner
John R. Turner, Jr
Robin T. Turner
Godwin C. Umozurike
Brenton E. Underwood
Bryan N. Walke
Celeste N. Wallace
Ahmad T. Ward
Tracy T. Webb
Karin M. Whedbee
Kimberly L. White
Florie B. Wigelsworth
Julia R. Wilkins
Mario L. Wilkins
Enetra N. Williams
June G. Williams
Xanda M. Williams
Craig L. Woodward
Vincent L. Wright

Honor List: 3.00 to 3.49 Average

Enver Alam
Stephanie F. Alexander
Lesley K. Alligood
Natasha M. Ames
Jennifer L. Amstutz
David B. Andre
Otika C. Archer
Sharon C. Armstead
Karen D. Backus
Brian D. Baker
Mary A. Baker
Darrick J. Banks
Elizabeth A. Banks
Melody Banks
Charles E. Barber
Juliene Barragan
Lisa A. Battle
Jennifer M. Beatley
Charles Belfield
Latasha S. Bembury
Raymond D. Bennett, II
Alayna D. Benson
Brenda D Best
Felicia N. Best
Kimmi M. Birth
Toney B. Black
Chanda L. Blount
Regina Blount
Myra W. Blow
April E. Bond
Crystal R. Bond
Khesa P. Bond
Anitra Boone
Monique L. Boyce
Larita M. Boyd
Loukisha R. Boyd
Vicky L. Braddy
Betsey M. Bradley
Patricia P. Brewer
Jerome R. Brite, III
Andrae' L. Brown
Angelina M. Brown
Pamela L. Brown
Yvonne Brown
Darick L. Bryant
Shelia T. Bryson
Kendra Y. Bunch
Lisa G. Bunch
Kevin E. Burdette
Kristi L. Burgess
Angela Burrus
Derrek W. Burrus
Edgar C. Burstion
Sabrina Butts
[illegible]
Tanya C. Chalk
James W. Cherry, II
Kimberly N. Cherry
Latonya L. Cherry
Kisha L. Clark
Vickie B. Cofield
Divern M. Combs
Robert L. Comstock, Jr.
Charna A. Cooper
Keishia N. Cooper
George D. Copeland
Brent P. Council
Tanisha S. Cowell
Aaron B. Cox
Marcus L. Croom
Claire E. Culbreth
Tammie S. Currie
Stacey N. Curry
Stephanie T. Dance
Kisha La'Rae Darden
Kenneth L. Davenport
Regina Y. Davis
Shondalyn L. Dawson
Clarence Dickerson
Adrian D. Dixon
Keisha N. Douglas
Felecia A. Downing
Jacquline G. Duncan
Brandon A. Egerton
Jo Ann Eiler
Re'ne L. Eller
Larry C. Elmore
Marjie L. English
Lakitra S. Evans
Lynn R. Evans
Keywonna S. Everette
Cleveland S. Faison, Jr.
Lavonna M. Felton
Arthur L. Fenner
Amy Ferebee
Nekesha D. Ferebee
Tracey M. Ferebee
Tyus S. Few, III
Carrie J. Fiedorczyk
Juanita G. Figgs
Kisha A. Figgs-Melton
Ralph S. Flowers
Abdoulaye Fofana
William F. Folkes
Wendy D. Forbes
Kirk A. Fox
Makeba Fussell
Syvillia M. Futrell
Tanisha H. Gabriel
Cherise S. Gardner
Patricia Y. Garner
Barbara G. Gibbs
Steven L. Gilchrist
Stephanie J. Gilliam
Veronica L. Goddard
Crystal O. Godfrey
Shirley J. Godfrey
Keashia T. Green
Charlotte S. Gregory
Julie H. Gregory
Michelle N. Grier
Tresha R. Griffin
Kimberly L. Grover
Charles C. Gunnings
Janet L. Hall
Natalie J. Hall
Laura E. Hanusik
Earnest Harris
Reginald M. Harris
Shantelle E. Harvey
Treneice C. Hassell
Nykeeya R. Hatten
Rose M. Hawkins
Kuchumbi L. Hayden
Karen M. Hayes
Tamara L. Hedgebeth
Shina D. Hemingway
Issac M. Hendrix
Inez T. Hoston
Kimberly A. Hunter
Nataniel D. Isaac
Hope M. Jackson
Cherelle K. Jenkins
Hope F. Jennings
Janet L. Jernigan
Sadie B. Jernigan
Denise Johnson
Tajima S. Johnson
Clarence M. Jones, Jr.
Harvey R. Jones, Jr.
Jermaine D. Jones
Joyce S. Jones
Kevin R. Jones
Sharlena R. Jones
Sharon R. Jones
Christie L. Kearney
Eugenia A. Kee
Herman L. Kemp
Crystal Keyes
Jennie B. King
Chastity J. Kinsey
Shondrieka N. Lamb
Bobby J. Lane
Antoine C. Lassiter
Shakellar L. Lassiter
Harold V. Lawson
Latonya N. Lee
Thomas E. Lee
Nelly M. Leigh
Jacob C. Leonard
Brian A. Lewis
Troy L. Lewter
Cynthia D. Lister
Chianti M. Lloyd
Linda F. Logan
Tonya F. Lyons
Kenneth E. Mabine
Kevin R. Markham
Michael G. Marshall
James C. Martin
Anthony A. Mason
Kenny L. May
Lavonne L. McClain
Carlos R. McCormick
Elizabeth A. McGhee
Trell D. McNair
Chantay P. McNeil
Eunice I. Meekins
Michelle L. Meketi
Demetrium D. Melton
Ralisha M. Mercer
April C. Molett
Barry D. Monk
Cynthia B. Moore
Dominique C. Moore
Dovella P. Moore
Elton K. Moore
Gerald C. Moore
Charmaine D. Morgan
Leslie L. Morgan
Kenya L. Morris
Michael D. Morris
Eric D. Mountain
Janice D. Mudge
Latisha D. Murphy
Latoya S. Murphy
Barron Neal
Terrica D. Nelson
Ronnell D. Nobles
Jennifer G. Nooney
Tonya A. Norman
Ginger H. O'Neal
Trequita D. Overton
Ramona L. Patrick
Takisha Q. Peacock
Jaime S. Peele
Allison F. Pendleton
Natasha D. Peters
Courtney N. Phillips
Dana C. Phillips
Jason K. Pipkin
Cindy L. Powell
Eric W. Powell
Kenisha L. Powell
Latasha R. Powell
Gwendolyn R. Poyner
Regina G. Price
Tangi S. Price
Traci L. Pritchard
Donetta R. Privott
Pamela O. Ransom
Debra M. Raymond
Peritha Redmond
Shena L. Reed
Dedric S. Reid
Rosa D. Riddick
Tamika D. Riddick
Thomas D. Ritchie
Edward K. Rivers
Christopher L. Roberts
Aquita C. Robinson
Keith L. Robinson
Troy L. Robinson
Eunice M. Rogers
Isaac C. Rogers
Antonio D. Rook
Kendra L. Rouse
Lashonda D. Ryan
Pete E. Salitore
Stefanie D. Saunders
Shericka N. Sawyer
Fred S. Sessoms
Pamela E. Shannon
Donna E. Shaw
Melanie S. Shaw
Latoya B. Sheard
Fredrika C. Simons
Alton Simpson, Jr.
Casandra L. Smith
Jason W. Smith
Kelli S. Smith
Angela D. Sneed
Brian P. Snow
Ernest B. Snow, Jr.
Tricia L. Speller
Tonda E. Spellman
Elbretia M. Spencer
Josephaina A. Spruill
Leigh A. Spruill
Latonya A. Square
Lisa A. Staton
Crystal I. Streeter
Tabetha L. Summerlin
Latangia R. Sutton
Nikita C. Sutton
Sheva V. Tate
Cher D. Taylor
Jose F. Taylor
Reshamah D. Taylor
Taneka S. Taylor
Andrea C. Temple
Felicia D. Thigpen
Sherri L. Thorpe
Annette K. Tiller
Drederick R. Tripp
Reginald D. Turner
Robert E. Turner
Bridget R. Twine
Marquita M. Valentine
Donald D. Van De Walker
Douglas J. Vann
Vanessa B. Vinson
Debra L. Wade
Nekia D. Walker
Reequita B. Walston
Chrishonda A. Walters
Darlene M. Waltor
Nikki S. Walton
Sephina Walton
Denese Ward
Gwendolyn Y. Ward
August V. [illegible]
Gary D. [illegible]
Vickie M. Whitbee
Tandeka L. [illegible]
Chengee B. [illegible]
Melissa E. [illegible]
Melissa R. [illegible]
Bryant L. [illegible]
Rhonda [illegible]
Debbie [illegible]
Alfreda R. [illegible]
Charles [illegible]
Janice [illegible]
Mikenette [illegible]
Ronald [illegible]
Vance [illegible]
Terri S. [illegible]
Constance [illegible]
Monte [illegible]
Lancelot [illegible]
Faith [illegible]
Tara [illegible]
Delicia A. [illegible]
Sharon A. [illegible]

Honors Fall Semester 1996-97

Chancellor's List: 3.75 to 4.0 Average

Rocky L. Allen
Karen P. Arizmendi
Marsha T. Bacenko
Karen D. Backus
Valerie W. Banks
David A. Bartley
Lakisha S. Basnight
Tammi Bass
Chenav Beamon
Philip M. Belfield
Thomas L. Blevins
Theo N. Bohn
Carmen T. Bolden
Susan J. Bourassa
Felica A. Bowser
Russell L. Boyd
Tammy B. Bray
Tonya M. Brinkley
Nicholas T. Britt
Craig A. Byers
Larry T. Cobb, II
Zellene S. Cochran
Abby R. Corprew
Louise I. Croswait
Karl B. Dail
Miles C. Daniels
Tarsha J. Darden
Cynthia R. Dashiell
Mark A. Delosreyes
Erica S. Derr
Ronda L. Dorsey
Lisa B. Earley
Debra L. Eason
Sharmel D. Edwards
Jo Ann Eiler
Michelle M. Ellinwood
Marita C. Elliott
Larry C. Elmore
Sandy R. Farrow
Jennifer F. Felton
Melissa J. Ferrell
Judith L. Fields
Scott L. Forbes
Mark K. Foster
Renee W. Foy
Patricia A. Frazier
Monte T. Freeman
Mary E. F. Friedman
Freda J. Garland
James C. Gibbons
Donna P. Gilbird
Steven L. Gilchrist
Allie B. Gladden
Katrina Y. Godwin
Ann H. Goodwin
Karen A. Griffin
Patricia S. Hall
Deborah A. Hamon
Diane M. Han
Katherine B. Harrison
Michael W. Hawkins
jacqueline R. Head
Tamara L. Hedgebeth
Mary S. Hobbs
Susan C. Hoggard
Bettina S. Holloman
Rachel A. Holmes
Melvin C. Hooker
Andre T. Howell
Frances E. Hughes
James M. Hunsinger
Melissa R. Jackson
Angela M. Jennings
Sandie B. Jernigan
Christopher K. Johnson
Lisa M. Johnson
William D. Johnson
Stephanie C. Johnston
Meri L. Jolin
Bessie C. Jones
Heather W. Jones
Kristie R. Jordan
Warren D. Judge
Sheryl A. Keagy
Jennie B. King
Rebecca U. Kirkbride
Kimberly N. Knight
Joseph Kurtzweil
Prescott P. Lawrence
Elaina M. Lawson
Harold V. Lawson
Pam C. Leary
Sonya B. Longest
Karen B. Lowe
Andrea D. Malik
Christi T. Martin
Shayne Martin
Susan S. McClanahan
James K. McClellan
Stacia L. McFadden
Ralisha M. Mercer
Cherrie A. Meredith
Tracy S. Mitchell
Cherie A. Morris
Julie A. Mutta
Arvin Q. Mullen
Mark M. Mwaura
Brenda S. Nash
Judith A. Newsome
Anna W. O'Brien
Karen A. Oakley
Veronica R. Overton
Mary C. Owen
Tracie R. Owens
Virginia G. Parker
Trina Y. Payne
Judy E. Peirson
Kenneth E. Perry
Cynthia M. Pritchard
Traci L. Pritchard
Robert W. Privott
Jennifer S. Pugh
Michael D. Pugh
Phillip E. Puryear
Benjamin G. Roberts, Jr.
Lee T. Robinson
Shelle R. Rust
Summer L. Sayers
Mary E. Schuster
Cliff R. Schweitzer
William E. Scott, Jr.
Beatrice K. Shearn
Casandra L. Smith
Brian P. Snow
Katherine G. Soria
Letitia L. Stevens
Bonnie W. Stoud
Angel P. Swimme
Cheryl L. Tate
Byron D. Thigpen
Ruth D. Thomas
Annette K. Tiller
Sunday K. Tinnell
Jamaal Turner
Porchia L. Unthank
Bryan N. Walke
Tamika C. Wallace
Betty T. Waters
Debbie L. Watson
Gary D. Whidbee
Timothy D. White
Marlo L. Wilkins
Laverne S. Williams
Pam M. Williams
Xanda M. Williams
Angie L. Winfree
Delicia A. Wright

Vice-Chancellor's List: 3.50 to 3.74 Average

Floyd C. Adams
Monica D. Alexander
Virginia L. Ambrose
Diane E. Andersen
Vivian A. Baars
Amy C. Banks
Sherry L. Bedsole
Tiffany R. Belfield
Demitrous R. Blount
Myra W. Blow
Monique L. Boyce
Floyd G. Bracy
Betsey M. Bradley
Rodshawn L. Branch
Kathleen J. Brooks
Angelina M. Brown
Caprissa S. Brown
Samantha L. Brown
Tahwana M. Burks
Bobby Burrus
Sabrina Butts
Beth A. Carpenter
Donald D. Charity, Jr.
Kristy S. Collins
Melissa W. Colombo
Michael A. Cox
Claire E. Culbreth
Tammie S. Currie
Lisa V. Davis
Samuel S. Davis, III
Andre' D. Dean
Jason C. Denham
Terry M. Edwards
Brandon A. Edgerton
Travis R. Evans
Janet R. Ferrell
Kisha A. Figgs-Melton
Ralph S. Flowers
Elouise Francis
Clarrissa E. Freshwater
Makeba Fussell
Ernestine Futrell
Kathleen D. Gaither
Melinda F. Gates
Charles L. Gatling
Joyce A. Godwin
Lorene R. Grunwald
Wendy S. Gurganus
Bethaney L. Hague
Charisse M. Harney
Carisa J. Harrell
Nicole M. Hoffler
Nathaniel D. Isaac
Norma F. Jeffcoat
Alicia M. Jones
Joyce S. Jones
Nathaniel L. Jones
Sheretta L. Jones
Lena L. Kee
Gary W. Kehner
Lecia King
Karlton L. Lane
Nathan A. Leonard
Linda F. Logan
Irving Long
James C. Martin
William K. Martin
Sharon C. Meads
Paula W. Mickey
Levar D. Mizelle
Rufus A. Moore
Willie D. Moore
Charmaine D. Morgan
Rebecca L. Myers
Terrica D. Nelson
Damond L. Nollan
Jennifer G. Nooney
Crystal Norton
Kendra L. Parker
Robin B. Pavey
Thomas E. Perry
Dana C. Phillips
Jason K. Pipkin
Tangi S. Price
Mashawnda E. Razor
Alisha M. Reid
Susan E. Roberts
Courtney E. Robinson
Paul I. Rose
Pete E. Salitore
Felicia A. Saunders
Elizabeth G. Sawyer
Franklin G. Scott, Jr.
Daniel L. Smith
Priscilla A. Smith
Samantha G. Smith
Angela D. Sneed
Donna T. Stiles
Karen S. Stokley
Amy W. Taylor
Reshamah D. Taylor
Varick T. Taylor
Felicia D. Thigpen
Vernecia V. Townes
Alvin Trotman
Donald D. Van De Walker
Rebecca L. Walston
Theresa L. Walter
Matthew W. Waymack
Kathryn R. Wiborg
Rhonda S. Wiggins
Enetra N. Williams
Pamela P. Williams
Tiki T. Windley

Honor List: 3.00 to 3.49 Average

Travis J. Albritton
Lesley K. Alligood
Kimberly D. Ambrose
Jennifer L. Amstutz
Melvin L. Anderson
Michael A. Arizmendi
Sharon C. Armstead
Pamela M. Armstrong
Marsha T. Atkins
Stephenie W. Bailey
Crystal L. Banks
Tynoshia D. Barnes
Sophona A. Barrett
Lisa A. Battle
Jennifer M. Beatley
Darrell L. Bell
Charles L. Berry
Heath L. Biggs
Natarsha Y. Bloomfield
Crystal R. Bond
Khesa P. Bond
Milton T. Bond
Jonathan B. Bonner
Latausha M. Boone
Tru'Vonda E. Boone
Valerie D. Bouldin
Quinterlene C. Bowen
Joshua S. Boyd
George T. Branch
Patricia P. Brewer
Joy H. Brickhouse
Jacqueline R. Britt
Otelia F. Brooks
Christine S. Buell
Richard S. Bullock
Kimberly R. Bunch
Tinika L. Bunch
Kristi L. Burgess
Justin J. Burk
Angela Burrus
Derrek W. Burrus
Jameka L. Cameron
Karen M. Carver
John J. Chapman
Annette E. Cherry
Ivy V. Cherry
Kimberly N. Cherry
Adam M. Collins
Kivern M. Combs
Lucy B. Cooper
Sharon D. Cooper
Erma R. Copeland
George D. Copeland
Wanda P. Currin
Giner S. Davenport
Kenneth L. Davenport
Uyless M. Dewberry, Jr.
Linda L. Dietzway
Danielle N. Drew
Felicia N. Drew
Robin J. Duckett
Jody J. Dunlap
Pamela S. Sunn
Rose H. Eakings
Peter M. Eley
Re'ne L. Eller
Corey M. Ellis
Arlinda F. Ellison
Marjie L. English
Raymond J. Epps
Keywonna S. Everette
Curtis W. Felton
Tracey M. Ferebee
Courtney D. Fields
Michael A. Fipps
Coletta R. Fleming
Wendy D. Forbes
Craig P. Foster
Kirk A. Fox
Syvillia M. Futrell
John C. Gambrell
Edward P. Garner
Robert C. Golden
Clarence E. Goss, Jr.
Tanya S. Granger
Benjamin C. Gray, Jr.
Keashia T. Green
Julie H. Gregory
Melvin Griffin
Bret M. Grubb
Kimberly L. Gruver
Rachel Marie S. Haines
Stephanie A. Haith
Euless M. Hall
Tamara J. Ham
Tami S. Harper
Keisha Harrell
Keisha L. Harris
Danielle Harrison
Andrea S. Harvey
Elnora Harvey
Treneice C. Hassell
Rose M. Hawkins
Kuchumbi L. Hayden
Bobbie J. Hayman
Antwane Heckstall
Issac M. Hendrix
Nikki S. Heyward
Barbara D. Hines
Kimberly T. Hines
Lashauna K. Hinton
Susan M. Hodge
Shanise L. Holder
James A. Jacobs
Cherelle K. Jenkins
Toinette T. Jenkins
Dollette M. Johns
Denise Johnson
Tajima S. Johnson
Brian A. Jones
Harvey R. Jones, Jr.
Hope Y. Jones
Kevin H. Jones
Kevin R. Jones
Maris D. Jones
Tyrone Jones
Yvette M. Jones
Brian N. Jordan
Ta-Tanisha D. Jordan
Neil A. Jordon
Quinton M. Joyner
Sheri D. Joyner
Tikisha R. Joyner
Rodridgeouz L. Kee
Robert H. Kelley
Crystal Keyes
Charles A. Lamb
Shondrieka N. Lamb
Bobby J. Lane
Telesh L. Lane
Stacey Layden
Monica S. Leary
Melinda L. Lee
Tanacia C. Lee
Jennifer V. Leonard
Brian A. Lewis
Clarence E. Lewis
Michael E. Lewis
Michelle E. Lewis
Troy L. Lewter
Dennis E. Linney
Cynthia D. Lister
Monica D. Littlejohn
Forrest W. Liverman
Chianti M. Lloyd
William E. Luton
Tonya F. Lyons
James G. Majette
Kenya T. Mabric
Menervia L. Mangum
Taneshia Y. Mangum
Deanna L. Marshall
Kenneth A. Mayuus
Chantay P. McNeil
Leah G. Midgett
Juasnita T. Mitchell
Shirley Montague
Andrea D. Moore
Anthony M. Moore
Ayonda D. Moore
Elton K. Moore
Gerald C. Moore
Tyrell L. Moore
Kenya L. Morris
Malanie M. Mule
Michael Munoz
Latisha D. Murphy
Tamisha S. Murphy
Tiffany M. Newell
Ronnell D. Nobles
Letisha Nowell
Giner H. O'Neal
Thanh Van On
Afua O. Opoku
Tori S. Padgett
Lillie B. Pailin
Kim S. Palmer
Damon L. Parker
Amy Parks
Jaime S. Peele
Melissa G. Pendleton
Clinton M. Perl
Shawanna Person
Tonya R. Peterson
Valerie T. Person
Brian K. Phelps
Teri S. Phthisic
Naomi R. Pittman
Shonda P. Pittman
Brenda D. Powell
Sypress J. Preston
Amy G. Priest
Eric B. Quidley
Monica L. Rascoe
Chelsea T. Raynor
Monica M. Razor
Dedric S. Reid
Jason M. Riddick
Marcus W. Riddick
Thomas D. Ritchie
Katina L. Roberts
Bonita J. Robinson
Peter J. Rodrigues
Jenny L. Roffo
Isaac C. Rogers
Polly J. Rollinson
Antonio D. Rook
Jennifer Ross
Tracia C. Rountree
Rashaun D. Rucker
Francis S. Sakala
Stephanie L. Scales
Fred S. Sessoms
Rhonda D. Sessoms
Brenda A. Seymour
Nadirah L. Shaw
Fredrika C. Simons
Tina D. Slone
Kelli S. Smith
Stacy M. Smith
Torie Y. Smith
Ernest B. Snow, Jr.
Spanishia D. Spragley
Josephaina A. Spruill
Tamika Y. Spruill
Yulanda N. Squire
Shirely M. Stallings
Kenya L. Stanley
Eric W. Staten
Danuail F. Stewart
Everett J. Stewart
Debbie K. Strawhand
Crystal I. Streeter
Tabwetha L. Summerlin
Stephanie M. Sutton
Alethea L. Swan
Tavon L. Tate
Tishania A. Tatem
Benjamin M. Taylor
Garrett T. Taylor
Andrea C. Temple
Yram S. Terry
Kenyatta M. Thomas
Luciana I. Thomas
Yushawnda R. Thomas
Terrance W. Thornton
Blair B. Todd
Jarrod W. Turner
Nikki D. Vinson
Nekia D. Walker
Darlene M. Walton
Sandra J. Walton
Sephina Walton
Ahmad T. Ward
Lynda J. Ward
Raymond L. Weaver
Twan D. Weaver
Donald K. Webb, II
Ryan R. Webber
Diane C. Whedbee
August V. Whidbee
Shaketa D. Whitaker
Tandeka L. Whitaker
Chengee B. White
Odell M. White
Ronald K. White
Stacy L. White
Clifford C. Whitehust
Glenna M. Whitehurst
Lisa Whitehurst
Gloria B. Wiggins
Debbie N. Wilkins
James A. Wilkins
Alfreda R. Williams
Anton Williams
Dawn N. Williams
Ebonie L. Williams
June G. Williams
Ronald D. Williams
Scottie O. Williams
Tanisha R. Williams
Tasha L. Williams
Timothy G. Williams
Jay Garrett Winslow
Justin R. Winslow
Iancelot D. Winslow
Shaquita E. Winslow
Faith Y. Winston
Xavier K. Wise
Dana L. Wood
Washuri N. Woodard
Colin R. Woodley
Terrence V. Wormack
Kimberly L. Wright
Sharon A. Wright
Tabitha S. Wright
Vincent L. Wright
Christopher S. Yacobi
Matthew D. Yelverton

Graduate Success Program Results

Name	University	Degree Sought/Earned
Jovita Harrell	Hampton	Masters Computer Science
Renee Basnight	Hampton	Masters Computer Science
Chonda Gayle	Hampton	Masters Computer Science
Eva Dail Koltuniak	Hampton	Masters Computer Science
Tim McCray	Hampton	Masters Computer Science
Sharon Saunders	Hampton	Masters Computer Science
Michelle Brown-Emmanual	Hampton	Masters Computer Science
Stephanie Vaughan	Hampton	Masters Computer Science
Cathy Thomas	Ohio State	Masters Computer Science
Felicia Bowser	NC State	Masters Computer Science
Clarence Jones	Hampton	Masters Physics
Michael Fields	Old Dominion	Masters Computer Science
Bonnie Gardner	Maryland	Masters Computer Science
Stacia McFadden	Michigan	Masters Computer Science
Cultilda Monk	Fayetteville	Math Education

Nurturing ECSU Research Talent (NERT) Program
Sponsored by
Elizabeth City State University
Office of Naval Research

Tuesday April 22, 1997 5:00 pm 116 LH

Fractals & Chaos Research Team
Dr. D. Sengupta, Mentor
Donald Charity, Fr/Math
Corey Ellis, Jr/Applied Math
Brian Jordan, Sr/Applied Math
Ayonda Moore, So./Applied Math
Tammara Ward, Jr/Math
Lakisha Mundon, So/Math

HTML/JAVA
Dr. L. Hayden, Mentor
Mrs. T. Chamberlain, Mentor
Courtney Fields, So/CS
Kuchumbi Hayden, So/CS
Katrina Godwin, Fr/CS
Shakiya Rodgers, Fr/CS

Statistical Analysis
Dr. M. Mannan, Mentor
Tamara McCray, Jr/AppliedMath
Arthur Fenner, Jr/Math
Toinette Jenkins, Fr/CS

ONR Final Research Team Reports

Thursday April 24, 1997 5:00 pm 116 LH

ATM Networks
Dr. L. Hayden, Mentor
Mr. D. Archer, Mentor
Curtis Felton, Jr/CS
Derrek Burrus, So/CS
Antonio Rook, So/CS
Fred Sessoms, Jr/CS
Stacia McFadden, Sr/CS
Charles Gatling, Jr/CS
Melvin Anderson, Jr/CS
Jamaal Turner, Jr/Ind Tech

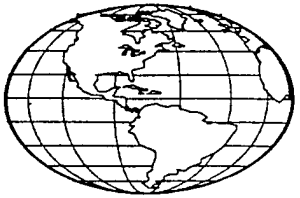
Visualization
Dr. K. Edoh, Mentor
Felica Bowser, Sr/CS
Laverne Williams, Jr/CS

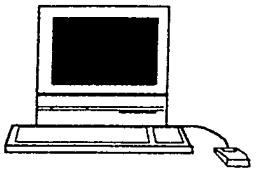
Computer Visualization Team Report

Computer Visualization Team

The focus of the computer visualization research is use of data explorer visualization software running on a silicone graphics workstation. Students run visualizations on NASA and chemistry data sets. Visiting Lecture will be presented by Sharon Ramsey, visualization specialist from Alcoa Aluminum Co. Review of the literature will include chapters from Animation and Scientific Visualization: Tools & Applications, Edited by R A Earnshaw and D. Watson, Academic Press, 1993. ISBN 0-12-227745-7. References will also include Communications of the ACM Dec'94, vol. 37, no 12 p 29-102.

Dr. K. Edoh
Team Mentor





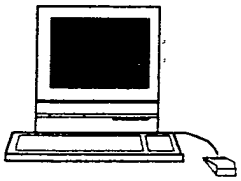
1996-97 COMPUTER VISUALIZATION TEAM

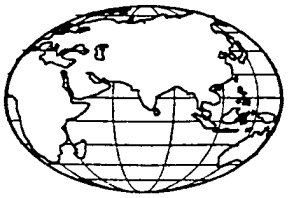
Dr. Kossi Edoh
Assistant Professor of Computer Science
Lester Hall 115
(919) 335-3234
kedoh@umfort.cs.ecsu.edu

Team Members:

Felica Bowser
Laverne Williams

Team Homepage:
/usr/users/student/bowser/CompVis





"VISUALIZATION OF NASA DATASETS"

OFFICE OF NAVAL RESEARCH

1996-97 COMPUTER VISUALIZATION TEAM

DR. KOSSI EDOH, MENTOR
FELICA BOWSER
LAVERNE WILLIAMS

Abstract

Rapid and extensive advances in three-dimensional computer visualization have developed and are making a major impact on many industries. The use of three-dimensional viewing has become an essential issue in several academic sectors and the commercial product development. Advanced endeavors are worthless unless the results can be clearly communicated. Meaning, some type of verbal and/or visual medium should be used to interpret the data and to report the results to others.

The 1996-97 Computer Visualization team had the task of visualizing data sets provided by NASA's Earth Radiation Budget Experiment or ERBE. The ERBE scanner instrument package contains three instruments used to measure shortwave, longwave, and total waveband radiation. Among all of the data, it was decided to visualize the longwave radiation data between the years of 1984 and 1989.

The software package IRIS Explorer was used to perform the task mentioned above. IRIS Explorer is a visual programming system for data visualization, manipulation, and analysis. The system has a programming component which developers can use for creating new applications, and a user environment in which the applicantions run. IRIS Explorer runs on all Silicon Graphics workstations and is available for other Unix-based workstations and supercomputers.

Introduction

What is computer visualization? It is a graphic representation of numeric data. Visualization involves receiving and interpreting data in order to output a pictorial example of the data. It is used to help researchers interpret numerical data and report their findings. Without computer visualization, advanced science modeling are worthless because they cannot be clearly communicated to others.

There are many software packages that can be used to perform visualization; IRIS Explorer is a system for creating powerful visualization maps, each of which comprises of a series of small software tools called modules. A map carries out a series of operations on a dataset and produces a visual representation of the result. Explorer consists of three main components:

(1) the DataScribe which is a data conversion tool for moving data between IRIS Explorer data format and other data formats,
(2) the Map Editor which is a work area for creating and modifying maps, and
(3) the Module Builder which lets people create their own custom modules.

In order to understand how these components work, one has to understand how a factory works. The purpose of a factory is to take raw materials (numeric data) and shape them into an end product (pictorial representation) according to a specific design. The raw materials are fed into an assembly line at one end, go through a number of alterations and manipulations as they pass through the machines (modules) on the factory floor (Map Editor), and then comes out at the other end in the form of a finished product (visual object or image). The product is inspected for qualities essential to the design; if they are not present or not satisfactory, the machines on the floor can be adjusted (purpose of Map Editor). The Module Librarian displays all available maps and modules. Single modules can be launched by dragging them into the Map Editor. Then they can be connected and wired according to their input and output ports.

DataScribe has three main functions:

(1) to convert data from an external source in ASCII or binary format into IRIS Explorer lattices,

(2) to convert to and from different data types within IRIS Explorer itself, and
(3) to convert data from one file format to another such as from ASCII to binary.

It creates scripts and control panels that can be saved as a module. The new module can be used in the map in order to convert the data to be used.

The Module Builder is used to build one's own IRIS Explorer modules. Existing IRIS Explorer modules can be modified and renamed, or new ones can be created. Module Builder's graphical user interface allows one to build a basic module with no programming beyond that needed to write the computational functions in C, C++, or Fortran. The module-building process has three stages:

(1) defining the internal structure, or "the engine"
(2) defining the external structure, or the user interface, and
(3) building and installing the module in IRIS Explorer.

Project Definition

The 1996-97 computer visualization team focused on visualizing NASA datasets provided by the Earth Radiation Budget Experiment (ERBE). The goals of the ERBE are (1) to understand the radiation balance between the Sun, the Earth, the atmosphere, and space which moderates the weather and climate system and (2) to establish an accurate, long-term baseline dataset for studying climate changes. ERBE's data files were contained in the following thirteen parameters:

- box center latitude, degrees
- box center longitude, degrees
- short-wave reflected radiation, watts/meter^2
- long-wave emitted radiation, watts/meter^2
- net radiation, watts/meter^2
- albedo, percent
- clear-sky short-wave radiation, watts/meter^2
- clear-sky long-wave radiation, watts/meter^2
- clear-sky net radiation, watts/meter^2
- clear-sky albedo, percent
- long-wave cloud forcing, watts/meter^2

- short-wave cloud forcing, watts/meter^2
- net cloud forcing, watts/meter^2

Due to time constraints, the long-wave emitted radiation was studied in this project. Fortunately, the data had already been gridded which means to be distributed on a uniform grid. In order to visualize the data in color, the RGB color scheme was chosen to represent the longwave radiation data. This project consisted of three concentrations: (1) DataScribe which involved the data conversion process, (2) Module Builder which assisted with the building or use of modules, and (3) Map Editor which performed the rest of the needed operations such as the design and assembly phases. Each concentration will be described in the following sections.

DataScribe or dscribe

DataScribe is a component of the IRIS Explorer visualization software package and was very important because it converted the gridded NASA data from ASCII into a lattice format that IRIS Explorer could understand. Several preparations had to be made before actually building the conversion module. They included knowing the format of the input referred to as scalars and/or array of scalars and deciding the format of the output data which comes in the form of lattices. The lattice data type consists of two parts: the data values and the position of the data values in Cartesian space. There are three types of lattices which come in one to three dimensional lattices. They are the uniform lattices (the most commonly used), the perimenter lattices, and the curvilinear lattices. The two dimensional curvilinear lattice was chosen for the output lattice because it best represented the data used.

In the setup of DataScribe, one has two templates: the input and the output. They can be differentiated by viewing the directional arrow in the top left-hand corner of the template. One also has a detailed and abstract view of the templates.

To build the conversion module to click and drag the desired glyph whether it is a scalar or lattice from the data type palette to the DataScribe workspace. Each glyph has its own parameter which should be specified by the user, and a component box that may be used for further specifications. Once all the glyphs have been

selected, the input and output templates must be wired or connected together which forms a script or module which is loaded in the Map Editor's Librarian. This is turn can be contained in a map with other modules. Lastly, a check should be conducted for errors by parsing the script to make sure all perimeters are correct in the glyphs and the templates are wired correctly.

Module Builder or mbuilder

As mentioned earlier, the Module Builder is used to assemble modules. The modules provided by IRIS Explorer offer a range of functions, but sometimes it is necessary to construct new modules, providing a more specific function or a greater capacity than the existing ones. At first, it was thought that new modules would have to be constructed. But, it was determined that the existing ones could be used with a few modifications. The three main stages had to be followed.

The definition of the internal structure involves creating a user function, defining the input and output ports, defining the function arguments, and defining the relationships between the inputs, outputs, and function arguments. An existing user function written in C programming language was used instead of a newly created function. The input port had to accept data in the form of the lattice data type. The module had to receive data on both its input port before it could fire, so each port had to be made a "Required" port. The output port produces a lattice output. The function arguments defined each function argument in the user function; each argument had to be connected to an input or output item. After all of the ports had been defined, they were properly connected. The proper connections are critical to the proper operation of the module.

The definition of the external structure involves designing a control panel and associating input parameters with control mechanims. A module has an interface that allows it to be controlled by the user. This interface is called the module control panel. Then the position, size, and limits of the control mechanisms were changed.

Finally, the construction and installation of the complete module finishes the process of module building. The module had to be turned into an executable program. The code was linked and

compiled during the build process. When this stage was complete, the new module was named "nasa_color", and it could be launched from IRIS Explorer's Module Librarian.

The Map Editor

IRIS Explorer's Map Editor is the environment in which maps are created and executed. The Module Librarian contains the available maps and modules. Maps can be used to perform a variety of tasks.

In visualizing NASA datasets, the modules were used to generate a visual image from a specified dataset. The modules used for the visualization can be grouped according to their general function:

- "nasa_color" read in the data files,
- "Contour" developed the geometric representations,
- "LatToGeom" performed the same function as "Contour" but with colors and structured patterns,

and

- "Render" created the images.

In order to execute the "nasa_color" module, a data file had to be entered into the text box. As the module fires, its title bar turns yellow and stays yellow until the module has completed execution.

It was decided that the data collected for all of the year of 1988 and the November data from the years of 1984 to 1989 would be used. A program written in C was used to change the longitude and latitude measurements from degrees to radians. The program also coordinated the color scheme of the radiation levels. Once all preparations were completed, the individual datasets were ran separately through the map in order to form the images.

Conclusion

The ERBE provided many mediums in order to measure variations of regional radiative parameters. The study and visualization of other parameters such as shortwave radiation and cloud forcing are considerations for future work for the visualization team. Also, efficiency in the visualizations could provide a means to predicting future climate changes. Contact with online users and other professionals could provide more insight into the world of visualization. It was observed that slight changes occurred in the longwave radiation each November over a four or five-year period. It can be loosely said that this is due to global warming of the earth. This observation needs further study.

REFERENCES

The IRIS Explorer Users' Guide
The IRIS Explorer Module Writers' Guide
"IRIS Explorer Center"
http://www.nag.co.uk:80/Welcome_IEC.html
The Numerical Algorithms Group Ltd, Oxford UK. 1996

APPENDIX A

CONVERSION PROGRAM

```
/*****************************************************************************
1996-97 COMPUTER VISUALIZATION TEAM
DR. K. EDOH, MENTOR
FELICA BOWSER
LAVERNE WILLIAMS
CONVERSION PROGRAM
*****************************************************************************/


#include <stdio.h>
#include <math.h>

void main()
   {

    float first, second, third;
    double oldlat, oldlong, newlat, newlong, shortwave, longwave;
    double netrad,  albedo, csshortwave, cslongwave, csnetrad, csalbedo, logfor;
    double shotfor, netfor;

    FILE  *in, *col, oldnasa, color;

    in  = fopen("data8411",  "r");
    col = fopen("ncolor8411",    "w");

    while(!feof(in))
        {fscanf(in, "%lf %lf %lf %lf %lf %lf %lf %lf %lf %lf %lf %lf %lf %lf ",
&oldlat, &oldlong, &shortwave, &longwave, &netrad, &albedo, &csshortwave,
&cslongwave, &csnetrad, &csalbedo, &logfor, &shotfor, &netfor);

       oldlong = oldlong * 3.14 /180.0;
       oldlat  = oldlat  * 3.14 /180.0;
    if ( oldlong > 3.14) oldlong = oldlong - 6.28;
       oldlong = oldlong * cos (oldlat);

/*         oldlong = oldlong * 2.0  /180.0;
          oldlat  = oldlat  * 2.0 /180.0;

      if( oldlong > 2.00) oldlong = oldlong - 4.00;
         oldlong = oldlong * cos (oldlat);            */


    if(longwave < 155.0)
                { first  = 1.0;
                  second = 0.0;
                  third  = 0.0;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
               else if (longwave < 160.0)
                { first  = 0.8;
                  second = 0.0;
                  third  = 0.0;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 165.0)
                { first  = 0.6;
                  second = 0.0;
                  third  = 0.0;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 175.0)
                { first  = 0.4;
                  second = 0.0;
                  third  = 0.0;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 185.0)
                { first  = 0.2;
                  second = 0.0;
                  third  = 0.0;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 195.0)
                { first  = 0.0;
                  second = 1.0;
                  third  = 0.0;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 205.0)
                { first  = 0.0;
                  second = 0.8;
                  third  = 0.0;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 215.0)
                { first  = 0.0;
                  second = 0.6;
                  third  = 0.0;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 225.0)
                { first  = 0.0;
                  second = 0.4;
                  third  = 0.0;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 235.0)
                { first  = 0.0;
                  second = 0.2;
                  third  = 0.0;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 245.0)
                { first  = 0.0;
                  second = 0.0;
                  third  = 1.0;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 255.0)
                { first  = 0.0;
                  second = 0.0;
                  third  = 0.8;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 265.0)
                { first  = 0.0;
                  second = 0.0;
                  third  = 0.6;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,

                /
```

```
third);
                }
                else if(longwave < 275.0)
                { first  = 0.0;
                  second = 0.0;
                  third  = 0.4;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 285.0)
                { first  = 0.0;
                  second = 0.0;
                  third  = 0.2;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave < 295.0)
                { first  = 0.0;
                  second = 0.0;
                  third  = 0.1;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }
                else if(longwave = 999.99)
                { first  = 0.5;
                  second = 0.5;
                  third  = 0.5;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second, third)
                }
                else
                { first  = 1.0;
                  second = 1.0;
                  third  = 1.0;
fprintf(col,"%7.2f %7.2f %7.2f %7.2f  %7.2f \n",oldlat, oldlong, first, second,
third);
                }

 }
```

Statistical Analysis Team Report

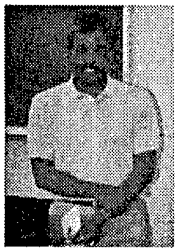
Statistical Analysis Team

The statistics team is responsible for the development of data concluded from research trips, meetings and other various seminars and lectuers. Our mission is to transform numerical data (appearing in the forms of various charts, graphs, and numbers), and transforming that data into a readable form.

The team gathered data from the 27th SIGCSE Technical Symposium and the Dr. C. D. Turnage Science, Math, Technology Scholars Program for Girls. The three steps that will be taken to achieve this goal are as follows: obtaining the data, converting the data, presentation of the data.

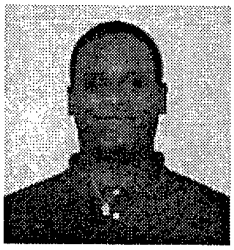
Arthur Fenner

Toinette Jenkins

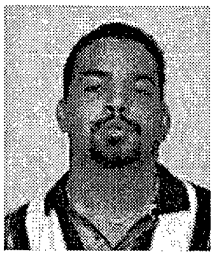


Dr. Mannan
Team Mentor

Tammara McCray



Charles Gatling



Fred Sessoms

THE STATISTICAL ANALYSIS TEAM

TEAM MEMBERS
DR. M. MANNAN(Mentor)
Arthur Fenner
Toinette Jenkins
Tamara McCray

ABSTRACT

The 1996-1997 Statistical Analysis Team had the honor of analyzing data taken from surveys which were designed to evaluate Dr. C. D. Turnage Science, Math, Technology Scholars Program for Girls. The program was designed to create a positive and permanent change in academic, social and scientific climates in order to allow the interest and aptitude women and girls display in science, engineering, mathematics to flourish. It also adds to the knowledge base about interactions between gender and infrastructure of science, engineering, and mathematics which can provide direction for further efforts. The purpose of the Turnage Program for Girls was to establish a comprehensive regional science, math, and technology program for girls through a partnership between Elizabeth City State University and Roanoke River Valley Consortium.

Statistics and Analysis Team
Toinette Jenkins
Arthur Fenner
Tamara McCray
Mentor: Dr. Mannan

The Evaluation of Gender Equity

-INTRODUCTION

Teachers and other instructional leaders completed a gender equity survey which quizzed them on whether they were fair to students of both sexes.

-PURPOSE

The purpose of this survey was to determine whether teachers were fair to students of both sexes and whether they displayed any type of discrimination to boys or girls in the classroom setting.

-DESCRIPTION OF QUESTIONNAIRE

The questionnaire was composed of twenty-seven questions in which the surveyor responded "yes" or "no" to each question that applied to the grade level in which they were associated with.

-METHODOLOGY

The results of the survey were computed by coding the status of each surveyor and coding each individual response. After all the responses were computed, a tally was then taken. After which, the percentage of yes, no, and non-applicable responses were computed. The data was then compiled into table format which displayed the question asked and the results of the responses to each question.

-RESULTS

After manipulating the data from this survey we were able to clearly see how many people answered yes or no to the questions and how many people had a non-applicable response.

Out of 52 surveyors:

PRE-K-GRADE 1

27% of the surveyors answered yes regarding inviting fathers to perform classroom roles traditionally filled by mothers.(Q1) Thirty-one percent of the surveyors answered yes to regarding whether they positioned themselves in certain areas of the classroom and on the playground to encourage girls and boys to play in nontraditional areas.(Q2) Seventeen percent invited parents and visitors with nontraditional careers to speak to the class.(Q3) Thirty-three percent required both boys and girls to participate in activities that encourage investigation and spatial exploration.(Q4) Thirty-seven percent expected both boys and girls to follow the rules.(Q5)

GRADES 2-4

Thirty-five percent encouraged students to work in single-sex

groups and cross-gender groups for cooperative learning projects.(Q6) Thirty-eight percent balanced their questions to both boys and girls in classroom discussions.(Q7) Thirty-seven percent stated that they answer all student's questions equally and give in-depth guidance to girls as well as boys.(Q8) Thirty-seven percent chose books and texts that women, men, and minorities in nontraditional roles.(Q9) Nineteen percent stated that they did not invite visitors in nontraditional careers to the classroom.(Q10) Thirty-three percent discipline boys and girls equally.(Q11) Thirty-eight percent have expectations for achievement in all subject areas are the same for boys and girls.(Q12)

GRADES 5-8

Thirty-three percent encourage cooperative learning in both single-sex and cross-gender groupings.(Q13) Twenty-eight percent stated that they balanced their questions between boys and girls.(Q14) Twenty-eight percent give help equally to boys and girls with the same expectations of results.(Q15) Thirty-three percent allow adequate time for problem-solving activities.(Q16) Nineteen percent invite visitors in nontraditional careers to the classroom.(Q17) Twenty-one percent provide encouragement and role models for boys and girls in the areas of spatial problem-solving,math, and science.(Q18) Thirty-one percent provide encouragement and role models for boys and girls in the areas of literature, political science, and the arts.(Q19) Thirty-one percent teach strategies for problem solving and conflict resolution.(Q20) Twenty-seven percent chose books and texts that have women, men, and minorities in nontraditional roles.(Q21) Thirty-one percent balance their request to both sexes for assistance with classroom management.(Q22) Twenty-nine percent balance affective questions and factual questions to both sexes.(Q23) Thirty-five percent balance their assignments of leadership roles to girls and boys.(Q24) Twenty-three percent encourage girls and boys to take on caregiver roles.(Q25) Twenty-one percent encourage physical activity in nontraditional sex roles.(Q26) Twenty-five percent test and quiz questions are worded in a gender-neutral fashion.(Q27)

-TECHNIQUES

The techniques and tools used in compiling and manipulating the data in this survey were an IBM computer in which we used the program MINITAB to help us translate the results to understandable data.

-RECOMMENDATIONS/SUGGESTIONS

In order to make this survey more accurate the surveyor should have been more specific of their position (status) of which grade level they taught and they should have answered only the questions which applied to them.

PARTICIPANT EVALUATION OF THE STAFF DEVELOPMENT ACTIVITY SURVEY

Responses to Questionnaire

Strongly Disagree Disagree

Undecided Agree Strongly Agree

1. The activity objectives were related to my educational concerns.
2. The activity objectives were related to practical educational application in my specific job setting.
3. The activity had some outstanding components which were unique or innovative.
4. Presentations were well organized.
5. The program schedule was well adapted to my educational needs.
6. My questions were satisfactorily answered by personnel conducting activity.
7. Meeting facilities were suitable.
8. The strategies utilized, including instructional resources, were appropriate for meeting the stated objectives.
9. Overall, personnel conducting the activity exhibited the qualities essential to the success of the workshop. (Consider creativity, specialized knowledge, communication skills, and the like.)
10. Overall, the activity was a successful training experience for me.
11. Adequate provisions were made for me to provide feedback to the personnel conducting the workshop.
12. Adequate provisions were made for me to identify needs which were not previously identified.
13. As a result of this staff development activity, I will alter my educational behavior in a more positive direction in my specific job setting.

The Participant Evaluation of the Staff Development Activity survey was assigned to evaluate the quality of the activity. The participants evaluate the activity by checking whether or not he or she strongly agrees, agrees, is undecided, disagrees or strongly disagrees with each statement. This survey has a total of 90 people participating in this particular activity which is unknown.

58.89% of the participants strongly agreed that the activity objectives were related to their educational concerns.

58.89% of the participants strongly agreed that the objective of the activity were related to practical educational application in their job setting.

67.78% strongly agreed that the activity had some outstanding components which were unique or innovative.

77.78% strongly agreed that the presentations were well organized.

51.11% of the participants strongly agreed that the program schedule was well adapted to their educational needs and 41.11% agreed.

65.56% of the participants strongly agreed that their questions were satisfactorily answered by personnel conducting the activity.

54.44% of the participants strongly agreed that the meeting facilities were suitable and 36.67% of the people agreed.

58.89% of the participants strongly agreed that the strategies utilized were appropriate for meeting the state objectives and 36.67% agreed.

74.44% of the participants strongly agreed that overall, personnel conducting the activity exhibited the qualities essential to the success of the workshop.

70% of the participants strongly agreed that the activity was a successful training experience for them.

71.11% of the participants strongly agreed that adequate provisions were made for them to provide feedback to the personnel conducting the workshop.

50% of the participants strongly agreed that adequate provisions were made for them to identify needs which were not previously identified and 41.11% agreed.

58.89% of the participants strongly agreed that as a results of this staff development activity, they will alter their educational behavior in a more positive direction in their job setting.

Overall, this particularly activity was effective. By this activity being so effective some of the participants are going to have a more positive attitude in their job setting.

-CONCLUSION

After all of the data was manipulated we were able to conclude that majority of the participants of this survey were fair to students of both sexes; they were also able to balance nontraditional sex roles in an equitable fashion. The results of this survey also displayed that the instructor created a classroom environment in which all children were free to live up to their potential.

Summary Report on Collegiality

This judgement of teacher opinion comes from 55 teachers interviewed on 'collegiality'. Their reports of their practice of collegiality varies from 'hardly ever' to 'almost always'.

About 47% 'quite often' allowed a free flow of ideas, and 29% did so 'as often as not'. Concerning the judgement of ideas on their merit rather than their source, 40% judge on merit 'quite often', and 33% 'as often as not'. Making suggestions to colleagues on touchy subjects was less popular: 42% 'not often' do so, and 22% 'hardly ever'. 44% agreed that 'almost always' and 25% agreed that 'quite often', their meetings include everyone who needs to attend them. 29% 'quite often' say that things are going well when actually they are not, and 25% 'as often as not' do so.

When asked if teachers receive respect as the key professionals in the educational enterprise, 27% responded 'as often as not', 25% 'quite often', and 25% 'almost always'. 42% agreed that 'quite often' authority and responsibility are shared, with 27% responding 'as often as not'. 33% said that 'quite often', 25% said that 'as often as not', and 25% said that 'not often' are decisions made by those most capable of making them. Personal and professional growth are 'quite often' encouraged, said 35%, with 27% apiece responding 'as often as not' and 'almost always'.

When asked if they take adequate time to discuss issues, reflect on them, and plan together, 38% said 'as often as not' and 25% said 'quite often'. Criticism is taken as a mark of disloyalty 'as often as not', said 36%, with 20% responding 'quite often' and another 20% responding 'not often'. 44% believe that the role of administrators as facilitators is encouraged 'quite often', and 27% 'almost always'.

35% say that 'as often as not' the organization seems as committed to them as they are to it, with 29% responding 'quite often'. When asked if identifying a problem is not only acceptable but is laudable, 36% responded 'as often as not' and 33% 'quite often'. Tthoughtful listening is appreciated 35% as 'quite often followed by 'almost always which is also 35%. The most important praise comes from the administrator or supervisor as 'quite as often' is 38% followed by 'not often' which is 18%.
31% said that 'quite often' they feel responsible for their colleague followed by 'almost always' which is 27%. 44% said that 'quite often' committee move from several suggestion to concrete procedure followed by 'as often as not which is 29%. 35% 'quite often agreed followed by 'as often as not' which is 29% for an honest conclusion that it is not working. 40% said ' as often as not followed by 'quite often' which is 25% for individual administrators model collegiality for teachers.

The *Who? Me?* survey was a survey of sexism and ask many questions dealing with whether the instructor was fair to both girls and boys in the classroom. The surveyors answered yes or no to the questions on the survey. There was a total of thirty people who answered the questions to the survey.

73.33% answered no to whether they expect boys to be loud and unruly, and girls to be quiet an well behaved.

96.67% answered no to whether they think girls have to try harder than boys to achieve.

86.67% answered no to whether they discourage boys from crying or expressing their emotions.

36.67% answered yes to whether they use sexist language like *policeman* or *mailman*, and refer to every nurse as *she* and every scientist as *he*.

36.67% answered yes to whether they assign duties based on gender stereotypes---like having boys to move tables and girls water plants.

96.67% answered no to whether they allow boys to monopolize the computers or playground equipment.

86.67% answered no to whether the pictures of men outnumber pictures of women on your classroom bulletin boards and visual materials.

76.67% answered no to whether they usually use books written by men and whether most of them feature men or show women only in traditional roles.

PERCENTAGE RESULTS

of the

Participant Evaluation of the Staff Development Activity Survey

Question 1	
4	38.89
5	58.89
9	2.22

Question 2	
4	38.89
5	58.89
9	2.22

Question 3	
3	2.22
4	30.00
5	67.78

Question 4	
3	4.44
4	17.78
5	77.78

Question 5	
3	2.22
4	41.11
5	51.11
9	5.56

Question 6	
3	4.44
4	27.78
5	65.56
9	2.22

Question 7	
1	2.22
2	2.22
3	4.44
4	36.67
5	54.44

Question 8	
3	2.22
4	36.67
5	58.89
9	2.22

Question 9	
3	2.22
4	23.33
5	74.44

Question 10	
3	2.22
4	27.78
5	70.00

Question 11	
3	2.22
4	26.67
5	71.11

Question 12	
3	8.89
4	41.11
5	50.00

Question 13	
3	4.44
4	36.67
5	58.89

Response Results

of the

Participant Evaluation of the Staff Development Activity Survey

1 - STRONGLY DISAGREE 2 - DISAGREE
3 - UNDECIDED 4 - AGREE 5 - STRONGLY AGREE

Question 1	
4	35
5	53
9	2
N =	90

Question 2	
4	35
5	53
9	2
N =	90

Question 3	
3	2
4	27
5	61
N =	90

Question 4	
3	1
4	16
5	70
N =	90

Question 5	
3	2
4	37
5	46
9	5
N =	90

Question 6	
3	4
4	25
5	59
9	2
N =	90

Question 7	
1	2
2	2
3	4
4	33
5	49
N =	90

Question 8	
3	2
4	33
5	53
9	2
N =	90

Question 9	
3	2
4	21
5	67
N =	90

Question 10	
3	2
4	25
5	63
N =	90

Question 11	
3	2
4	24
5	64
N =	90

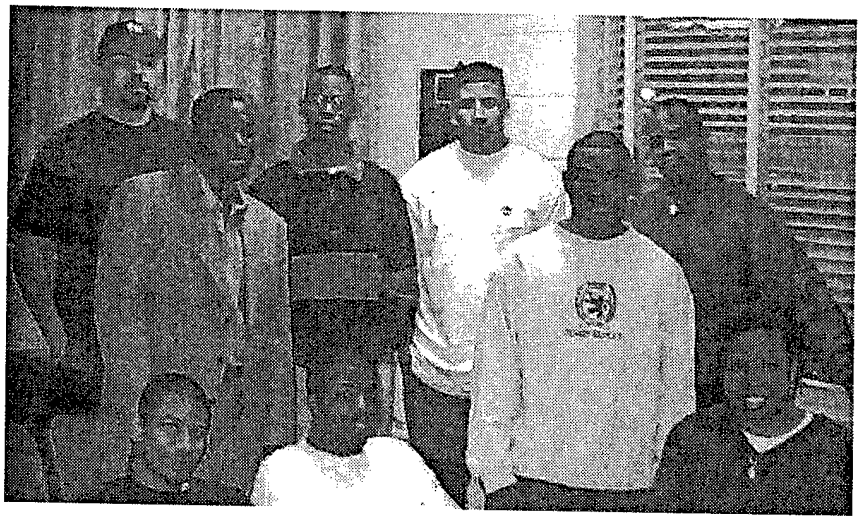
Question 12	
3	8
4	37
5	45
N =	90

Question 13	
3	4
4	33
5	53
N =	90

ATM Networks Team Report

ATM Networks

The focus of the Networking Research in on Issues, challenges and Installation of **A**synchronous **T**ansfer **M**ode **(ATM)** networks in 115 Lester Hall and the conversion of the campus backbone to ATM. Student researchers get hands on experience while assisting with the installation of ATM Network to the desktop in Lester Hall and conversion of the campus backbone. Visiting Lecture have been presented by ADNET Systems, Inc, Jerry Trott, UNC-GA System Administrator, and Sunsil Punoose. Review of the literature will include articles from the Communications of the ACM, Feb. 1995, Vol. 38, no. 2, p 28-109.



ABSTRACT

Asynchronous Transfer Mode (ATM) is a connection-oriented transmission protocol, based on fixed-length cells of 53 bytes. ATM is predominantly utilized as a means of solving network inefficiencies while increasing the productivity of the network's users. Developed in the United States by Bellcore Laboratories, ATM serves as a means of communication between both Local Area Networks (LAN) and Wide Area Networks (WAN). The System Administration/ATM Networking research team at Elizabeth City State University will attempt to reaffirm the theory that ATM is a faster and more efficient means of network communication than Ethernet.

In order to perform the tests which are necessary in achieving the goals of reaffirmation, the research team must conceive a testbed. A testbed consists of the hardware and software required to verify the team's theory that ATM is the better means of data delivery and retrieval. The information that is recovered from the testbed will be obtained through benchmark testing. Benchmark testing measures the performance of a system or a subsystem on a well-defined task or set of tasks. These test are utilized in three ways: to predict performance, to ensure the minimum performance in a procurement specification, and as monitoring and diagnostic tools. By employing the elements necessary the research team will reinforce the notion that ATM is a faster more efficient means of data retrieval and delivery than Ethernet.

System Administration/ATM Networking Team

Final Report April 24, 1997

Mentors:
Dr. Linda Hayden
Darnley Archer,
NASA Network Manager
Office #113B
Phone 335-3645
email: darcher@umfort.cs.ecsu.edu

Melvin Anderson
Derrek Burrus
Curtis Felton
Charles Gatling
Stacia McFadden
Antonio Rook
Fred Sessoms
Jamaal Turner

URL:
http://www.ecsu.edu/onr/atm.html

Introduction

In today's rapidly advancing technological world, the delivery and retrieval of data becomes critical in the world of computer networking. One of the ways network managers are trying to keep up with endusers demands for rapid transfer of data, is to provide them with high bandwidth. To provide high bandwidth, network managers are exploring the capabilities of Asynchronous Transfer Mode (ATM). Our research will explore the essential elements required in comparing both ATM and Ethernet while analyzing results yielded from our testing. The project test the existing theory that ATM is a faster and more proficient means of data delivery than Ethernet.

Overview

ATM

ATM is defined as a connection-oriented transmission protocol, based on fixed-length cells of 53 bytes. It is a means of communication used for both Local Area Network (LAN) and Wide Area Network (WAN) technologies. A LAN is a network which interconnects PC's, terminals, workstations, servers, printers and other peripherals at a high speed over short distances. An example of a LAN is a computer lab within a building. A WAN is a network which connects users across large distances often crossing the geographical boundaries of cities and states. An example of a WAN is a group of buildings on a campus interconnected.

The origin of ATM cannot be linked to a particular group. It is said in the United States, Bellcore Laboratories were the first to propose the ideas behind ATM. While in Europe, several large telecommunication companies were developing their own ideas for ATM.

Being the "new technology on the block" everyone is trying to utilize it in various applications. Therefore, standards must be set on how it is to be used to the extent of its networking capability. The foremost group handling issues such as this is the ATM Forum. The ATM Forum is a consortium of organizations representing vendors, manufacturers, carriers, service providers, universities, research groups, consultants and users that make recommendations and define specifications for ATM. The ATM Forum also promotes industry cooperation in the implementation of ATM technologies to transfer packets across both private and public networks, and encourages the development of products that involve the use of ATM technologies (ATM Forum, http://www.atmforum.com).

The ATM Forum is currently looking for more prevalent areas in which to expand ATM. One of the major aspects that would allow many of these expansions to take place is the use of emulation. Emulation is a technology that allows excess bandwidth within network lines to be used therefore, maximizing the transferal of data between two existing points. By using emulation more data can be sent or received than by using regular data transmission methods. Without emulation, waiting for bandwidth within a network line to be allocated for use could bring up the possibility of the loss of bits, resulting in the loss of packets, which ultimately results in the loss of data.

The use of emulation in ATM gives it an advantage over other networking protocols by allowing transmission of data from point to point

to travel faster. With technologies such as this, ATM is beginning to be used for more tasks. Multimedia servers are becoming feasible because of this and the standards associated with it. Transmission of other data such as voice are also becoming possible with the use of ATM for companies, universities, etc.

Another new use of ATM is running real-time applications. Video conferencing is a discussion between two or more groups of people who are in different places but can see and hear each other using electronic communications. Sound and pictures are carried by a telecommunication network such conferences can take place across the world. With the help of ATM, video conferencing allows the user to communicate with other users as if they were standing face to face.

Testbed

In order for the System Administration/Networking team to make a logical comparison to ATM, we had to define our testbed. A testbed includes the hardware, software, test tools, and environment, all of which are necessary in conducting tests. A well devised testbed will ensure all of the needed materials are readily accessible. The following paragraphs will define our testbed.

One component of a testbed is the actual hardware used. Hardware consists of any physical equipment such as workstations, switches, hubs, and various other devices. Our testbed consists of an ATM Switch, Ethernet Hubs, an Ether Switching Hub, Fiber Distribution Centers, and Silicon Graphic workstations with ATM Cards.

The next component of the testbed is the software being used. The software includes the operating system, applications, or test tools. IRIX 5.3 is the operating system being used and InPerson is the software test application for desktop video conferencing. The test tools are used to test the software or equipment the researcher is using. Two examples of test tools are Netperf and TTCP. Netperf and TTCP are benchmarks that can be used to measure various aspects of networking performance. Currently, their focus lies in determining UDP (User Data Protocol) or TCP (Transmission Control Protocol) performance between two systems.

Finally, the environment is an important component of the testbed. This will be the place where most, if not all, of the testing will be conducted. An environment can range from a lab to an office. For instance, our environment consists of a communication closet which includes an ATM switch, Ethernet Hubs and switches along with a computer lab consisting of SGI workstations.

Benchmarking

Using software to retrieve data about hardware components, is commonly referred to as benchmark testing. To better understand benchmark testing, we must first formally define the term. A benchmark is a point of reference from which measurements are made. In computer science, "A benchmark is a test that measures the performance of a system or a subsystem on a well-defined task or set of tasks."

Benchmarks are commonly used in three ways: to predict performance, to ensure the minimum performance in a procurement

specification, and as monitoring and diagnostic tools. Benchmarks can predict the performance of an unknown system from the results of a known system. By running benchmarks and comparing the results against a known configuration, one can potentially pinpoint the cause of poor performance. Similarly, a developer can run benchmarks after making a change that can effect performance. Benchmarks can measure graphics, input/output, computations on integers and floating points, and communication performances. Most benchmarks measure specific tasks which include rendering polygons, reading and writing files, and performance operations on matrices.

ATM Testbeds

The NCSA/UTRC testbed consisted of 2 Fore Systems switches, a Sun SPARCstation, and SGI Indigo workstations. The testbed configuration was that of a Sun SPARC workstation and a SGI Indigo connected to an Fore ASX-100 switch. The testing software used was nettest. Nettest measures memory to memory transfer of data, therefore making it a more accurate estimate of network throughput. The nettest options used were packet size, transport layer protocol, window size, and the number of packets sent. The results concluded that the average read throughput (performance measurements for reading data sent from the SGI) was 11 Mb/s and the average write throughput (throughput on write operations from the Sun to the SGI) was 40 Mb/s.

To test the accuracy of your test you must have tests to compare them with. To compare the tests both your tests and your test tools and theirs must be identical or very close. If not, your results will not be very accurate. In a test found from IAIK, they were testing the ATM TCP (transmission control protocol) performance of different workstations such as ULTRA SPARC, SPARCstation 10/512, and a SGI Power Challenge. The achieved throughput is compared to the theoretical limit which is about 135 Mb/s when reducing the bitrate of a 155Mb/s OC3 link by the SONET overhead, the AAL5 overhead, and the ATM cell overhead. In one test between a SPARCstation 10/512 and SGI Power Challenge where the SPARCstation was the machine sending the data and the SGI Power was the machine receiving the data, the measured maximum TCP performance was 60.98 Mbit/s with the percentage of maximum theoretical limit of 45.33%. In another test, ULTRA SPARC was the sender and SGI Power Challenge was the reciever, the maximum TCP performance was 100.73 Mbit/s at a percentage of 74.88%.

Ethernet Test Results

The System Administration/ ATM Networking Team used TTCP (which was found on the internet) to test the Transmission Control Protocol (TCP) over Ethernet from Indy to Indy. TCP is a standardized transport protocol developed for interconnection IP-based networks. TTCP times the transmission and reception of data between two systems using TCP or UDP (user datagram protocol).

In order to run TTCP, we compiled it as you would any C program so we could use the a.out file. Then the receiver types in a.out -r -s followed by the transmitter typing in a.out -t -s plus the name of machine receiving the data.

-t = transmit mode
-r = receiver mode
-s = if transmitting a data pattern to network and if receiving sink (to discard the data). Otherwise it will transmit data from stdin or print received data to stdout.

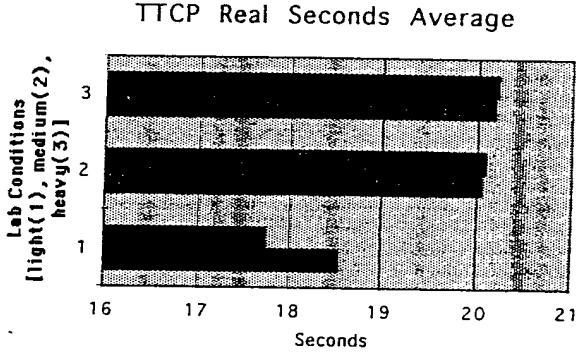
After running our test we took the average of three light, three medium, and three heavy lab conditions. We then graphed the Real Seconds and Kilobytes/Seconds (which is the format of the throughput rate) using Microsoft Excel. In one set of test, we used the processes being ran on the systems at that time and for the other set we used the processes running plus InPerson.

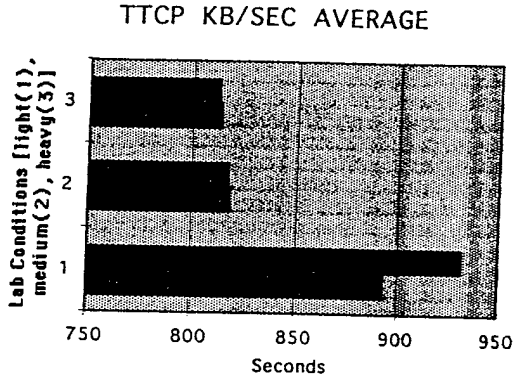
Note: There may be some discrepancy in our results do to events beyond our control.

TTCP.C INDY TO INDY TEST RESULTS CHART
AVERAGE

	LIGHT	MEDIUM	HEAVY
SENDER			
REAL SECOND	18.53	20.04	20.16
KB/SEC	892.91	817.48	812.99
RECEIVER			
REAL SECOND	17.73	20.07	20.19
KB/SEC	931.25	816.67	811.70

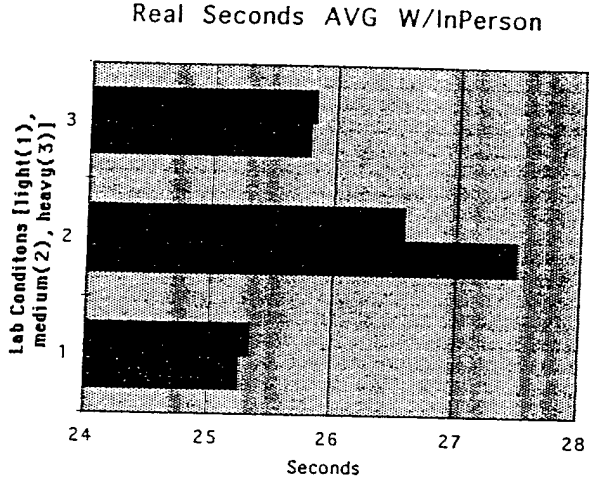
Looking at the data above for both the sender and receiver, as the real seconds increase under the different lab conditions (light, medium, and heavy) the kilobytes/seconds decrease. The bar graphs below show the results of TCP in real seconds and kilobytes/second between the sender and receiver in relation to the lab conditions.

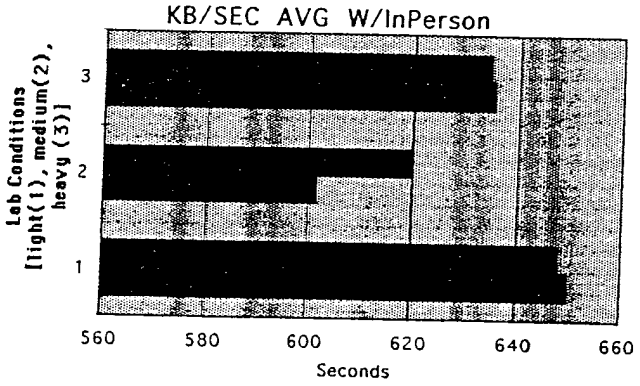




TTCP INDY TO INDY TEST RESULTS AVERAGE RUNNING INPERSON			
	Light	Medium	Heavy
SENDER			
Real Second	25.23	27.47	25.79
KB/Sec	649.98	601.23	635.23
RECEIVER			
Real Second	25.31	26.56	25.83
KB/Sec	647.81	619.47	634.45

The data above is from the TTCP test we ran while using InPerson. Below are the bar graphs of real seconds and kilobytes/second test results we found.





Our test results, show how the transmitter and receiver transmission control protocol data transferring rate varies under different conditions. Some of the conditions that affect the rate of

data being transferred are the number of people in the lab, the number of processes being ran on the system, and how many packages are being sent during testing. After comparing both ATM and Ethernet test results, you can see that ATM has a faster transmission rate than Ethernet.

Summary

As ATM is becoming a leading technology in the field of computer science, more and more people are pursing new avenues in which to advance ATM and its technology even further. But in order to accomplish this, test have to be run to ensure the capability and compatibility of ATM to a specific network.

Within our tests, Ethernet was used to run test using our current networking setup. These test results were compared to the ATM test results we obtained. These test results yielded that ATM was faster than Ethernet. The next steps include implementing the same tests that we ran with Ethernet on ATM. We will begin this phase of our report when ATM is implemented within our computer science department. In conclusion, we would be able to fully test and understand the capability of ATM.

BIBLIOGRAPHY

ATM Forum, The. WWW:http://www.atmforum.com/. (March 25, 1997).

Blais, Robert D. of ATM Consortium. email: rdb@iol.unh.edu

Cisco Systems, Inc. *Asynchronous Transfer Mode.* WWW:http://www.cisco.com/. (1997).

Dyson, Peter. *Novell's Dictionary of Networking*(. San Jose: Novell Press, 1994.

Greenfield, David. *Top-Flight Video Makes It to ATM.* WWW:http://www.data.com/Hot_Products/ATM/Top_Flight_Video.html. (January 1996).

Hammond, Richard and Cliff Woolever. *Computer Network Architectures & Network Programming.* WWW:http://jliusun.bradley.edu/~jiangbo/cs343/atmprj/homepage.htm#CS343. (September 30, 1996).

Johnson, Johna Till and Robert Mandeville. *Forget the Forklift.* WWW:http://www.data.com/Lab_Tests/Forklift.html. (September 1996).

Koester, Dr. David P. *Asynchronous Transfer Mode (ATM) Technology Web Knowledgebase--- An ATM Primer.* WWW:http://www.npac.syr.edu/users/dpk/ATM_Knowledgebase/getting_started.html. (1997).

Kolias, Christos. *The ATM Glossary.* San Jose, CA: McQuillan Consulting, Inc. 1996.

Leitold, Herbert. *ATM Activities- ATM Performance Evaluations.* WWW: http:// www.iaik.tu-graz.ac.at. (March 12, 1997).

Narayanan, Ravi and Tony Rybczynski. *ATM Gets Real About Real-Time Apps.* WWW:http://www.data.com/tutorials/realtime_atm.html. (October 1996).

O'Mailey, Dennis M. *Asynchronous Transfer Mode.* WWW:http://www.gl.umbc.edu/~domail1/. (December 19, 1995).

Quigley, David. *Asynchronous Transfer Mode.* WWW:http://hamming.mathcs.carleton.edu/students/quigleyd/project.html.

Ramakrishnan, K.K. and Peter Newman. *ATM Flow Control: Inside the Great Debate.* WWW:http://www.data.com/Tutorials/ATM_Flow_Control.html. (June 1995).

Rangarajan, Vijay and Charles H. Rothauser. *ATM LAN/WAN Performance Analysis of NCSA/UTRC and Supercomputing '94 Networks.* WWW:http://vger.res.utc.com/.

Singh, Sheilly of ATM Forum. email: ssingh@atmforum.com.

Strickland, Dancil. Intel Scalable Systems.

Taylor, Kieran. *Voice Over ATM: A Bad Connection.* WWW:http://www.data.com/Tutorials/Voice_Over_ATM.html. (February 1996).

Thing, Lowell. *Whatis?com Inc..* WWW:http://www.hudsonvalley.com/.

West Net, Inc. WWW:http://www.wni.net/wnet7.html.

HTML/JAVA Team Report

HTML/JAVA Team

Student HTML/JAVA researchers learn to produce documents in Hypertext Markup Language (HTML), the language used on the World Wide Web to create web pages. The web pages include: backgrounds, images, animated GIF images, tables, frames, JAVA applets, and shockwave technology.

Researchers are responsible for maintaining and updating the ONR/NERT web pages. Students also setup and maintain a http server for the ECSU homepage and are responsible for updating and maintaining all web pages for the university's homepage. They assist students, staff, and faculty in the scanning of logos and photos to be incorporated into web pages.

HTML/JAVA Team

Team Mentors: Mrs. Tracy Chamberlain, Dr. Linda Hayden

Team Members

Courtney Fields, Sophmore/Computer Science Major
Katrina Godwin, Freshman/Computer Science Major
Kuchumbi Hayden, Sophmore/Computer Science Major
Shakiya Rodgers, Freshman/Computer Science Major

Abstract

The first generation of static World Wide Web Pages is gradually giving way to dynamic sites with elements that bounce, shake, shimmy, swirl, sing, and scroll. There also is a steadily rising number of elements with which users can interact. This has become possible through new technologies that enable browsers to handle in-line video, real-time audio, and animated graphics.

Student HTML/JAVA researchers will learn to produce documents in Hypertext Markup Language (HTML), the language used on the World Wide Web to create web pages. The web pages will include: backgrounds, images, animated GIF images, tables, frames, JAVA applets, and shockwave technology.

Researchers will learn to use JAVA to enhance our current web pages. JAVA connects with HTML and the web through a special HTML tag called APPLET, which allows developers to included special JAVA programs on Web pages. Students will integrate applets into existing web pages as well as create their own applets.

Researchers are responsible for maintaining and updating the ONR/NERT web pages. Students will also setup and maintain a http server for the ECSU homepage and are responsible for updating and maintaining all web pages for the university's homepage. They will assist students, staff, and faculty in the scanning of logos and photos for incorporating into web pages.

The HTML/JAVA team consists of Computer Science majors this year. Each of us brings creativity to the team. The team members are our mentor, Tracy Chamberlain, Kuchumbi Hayden, Courtney Fields, Katrina Godwin, and Shakiya Rodgers. This year we have reviewed articles, learned HTML, made our own webpages, assist with training, assemble the ECSU Homepage, and much more.

HTML, which stands for HyperText Markup Language, is a type of SGML (Standard Generalized Markup Language). It is usually a plain-text document that can be created under any text editor. HTML uses a series of tags in order to create a document (referred to as a webpage) that can be viewed on a browser, across the Internet by accessing a URL (Uniform Resource Locator). HTML documents provide valuable information for all types of organizations. From NASA, to the latest trends in fashion, to the closing figures in the stock exchange. Information at these sites and locations are changing all the time. Thus, many of these locations have what is known as a webmaster in order to keep the page maintained. This job is one of significance. Not only does the organization get to see the work the webmaster has done, but everyone that visits the site.

At the beginning of the fall semester, our mentor, Tracy Chamberlain presented every team member with a HTML Reference Manual. The manual described and defined elements which were used to tag and code text. In addition, the team had to gain some background knowledge on the World Wide Web and various languages such as HTML. We were instructed to read an article titled, *World Wide Web: Whence, Whither, What Next?*. It concerned the past, present, and future of the World Wide Web dealing with the different markup languages. After we read the article, each of us typed a one page report that summarized the article. If we did not turn the summary in on time, we had to read another article titled *Publishing on the World Wide Web: Organization and Design* and write another summary.

The team's first hands-on experience with HTML was the *Beginner's Guide to HTML* booklet. We read through the material discussing the various tags, what they stand

for, and how and when to use them. Besides text, the booklet contained samples of HTML tags. The team members opened a jot file in his or her account and began to do the practice tags. We learned the bold, center, italic, and font size tags. In addition, the team members could change the background, text, and link colors by using several combinations of letters and numbers. We learned how to open a file in Netscape to see the results of what we typed in the jot file. As the team began to progress, we began to make tables, frames, and other advanced features. We also downloaded and saved images and backgrounds into our accounts.

Our next assignment was very simple. We had to make sure that all of the links on the NASA school partners page were working. If a link was not working or if a page was under construction, then we had to write down the URL of that link or page. This took a little bit of time because every school had their own page with many links. Some of the schools included Emily Spong Elementary, Douglass Park Elementary, and many others. After the errors were located, the links were fixed.

The team also created a webpage for NetDay96. The idea behind NetDay96 was to get wiring installed in classrooms in selected secondary schools in North Carolina and Virginia. This allowed computers to form a local network and link to the Internet or other wide area networks. We typed newspaper articles in a jot file in the JAVA account and saved them into the NetDay96 folder. The newspaper articles pertained to the purpose of NetDay96, the participating schools, volunteers, and what would happen during NetDay96. Some of the items were from *The Daily Advance* and *The Virginian-Pilot*. Others were documents for Douglass Park and Emily Spong. Celebration of having ATM wiring in their schools for the Internet. After the documents were typed, the team put in HTML tags to change font size, to make certain text bold or italic, and to make the article appear presentable on the World Wide Web.

The Math and Computer Science page was a more challenging task for the HTML/JAVA team. We had to work hard on the page so it could be put into the ECSU homepage. First of all, each team member was assigned three or four professors. We obtained the professors' resumes and took their pictures with the Quick Cam. We gave the professors' resumes computer backgrounds with their names in H1 font and their pictures. Depending on the amount of information that was on the resumes, different links were created for each section, like experiences, education, etc. For some of the sections, tables were created because there was so much information dealing with dates, degrees, and descriptions. In the table it is easier to read and understand. After we finished the professors' resumes, links, grammar, and correct information were checked.

The HTML/JAVA team is very dedicated. We spent part of our Christmas break working on various HTML documents in the computer lab. The team worked on the NRTS training page. We typed in the various workshops that people could attend, explaining each one, and how long the workshops would last. Furthermore, several links were made to the NRTS training page. The pages were then checked for defective links and grammatical errors. Then we labored on different parts of the ECSU homepage. We opened the ECSU page folder and different jot files to make sure the links were working, icons were appearing, and the text was grammatically correct. The team went through several curriculum guides to make sure everything was functioning. We also continued to toil over the NetDay96 page during the break. We had to make links from the NetDay96 main page to the articles that were typed earlier this year. After that task was completed, pages of pictures were created of the schools that were involved in NetDay96 and made links from the main page to the pages of the pictures. The pictures were various volunteers who helped out in NetDay96 and some of the schools were Sheep Harney Elementary, Camden County High School, among others.

Throughout the year the HTML/JAVA team has assisted with various training workshops. From October 31 to November 2, 1996, the Fall Training Event took place in Lester Hall. Some of the sessions that HTML participated in were WWW Search Engines, Graphics on the Internet, Graphics Converter, and GIF89 a Animation and Sound. Also

from September 23 through October 4, 1996. Workshops for Faculty took place in 115 Lester Hall. There were numerous workshops on retrieving information from the internet, search engines, and electronic discussion groups. On Friday, December 20, 1996, there was a Microcomputer Applications workshop in which HTML played a role. Some of the sessions were Intro the the Internet, Homepage Design, and the World Wide Web.

The team's biggest and most challenging project of the year ws the ECSU homepage. We worked on the ECSU homepage in the AcadResearch directory. We had to create directories for the various Academic departments like the Art, Education, Geology, Social Studies, and etc. Then the appropriate files and pictures were placed into the directories that were pertaining to them. Everything had to be documented. For example, the names of all the files that were put into the separate directories had to be written on a sheet of paper. We proofread each HTML file in the directories and inserted a certain address where there was an img src tag and a certain address where there was an a href tag. Next, the team had to create new directories for different programs like the Aid Program and the Bookstore. We followed the same procedure for the new directories. At the bottom of almost all of the HTML documents, was a table that had to be corrected. The addresses had to be changed, certain links removed, and new addresses added. In addition, the team checked for errors in the documents and corrected them, if any. There were a few grammatical errors in a few of the documents. On February 4, 1997, the New ECSU Webpage was shown at the Umfort Locus Dedication Ceremony.

Each member of the team viewed the ECSU page on a different web browser like Mosaic 2.0 and Mosaic 3.0. We had to find out the differences between the latest browser and the old browser. On Mosaic, there was no centering, font color, or pictures. Now the team is making an all text version of the ECSU homepage for such browsers.

Each member of the team is currently working on his or her homepage. Some of the items that are mandatory are varied font sizes and colors, separators lines, unordered lists, animated gifs, photo, resume, and a background along with many other features.

The HTML/JAVA team has worked long and hard on the various assignments throughout the year. We started from the bottom and worked our way to the top. The team began with writing articles to creating and editing the ECSU webpage. Without HTML and other SGML's, there would not be the creative webpages we see today.

The World Wide Web, in a time frame about five years has become the most popular Internet application. It has made significant contributions to the Internet. The World Wide Web allows users to retrieve text and multimedia objects from servers located throughout the world, with. objects connected by hypermedia links.

The underlying central functionality or Internet technologies of the Web are rather simple. The naming mechanism or the universal resource locator (URL) a typed, stateless retrieval protocol, and a minimal formatting language with hyperlinks. All of the basic technologies were around prior to the "invention" of the Web, generally credited to Tim Lee and Robert Caillou at CERN. However, the major accomplishment was not an individual protocol, but rather the integration of desperate pieces into a new more powerful way of using networks. the Web really didn't take off until the original ASCH-only browser was replaced by one based on X, did the Web really take off. Though originally conceived to integrate existing retrieval and access mechanisms.

In the early 1990's, there was a demand by every cable and telephone company to try-out trial versions of various forms of video-on-demand services, such as home shopping and banking, would be similar to what is now slowly emerging on the Web, but the pool of providers would have been strictly controlled by the cable or telephone operator.

The roles of on-line services relative to the Web has seen much discussion, with some dismissing the on-line service providers as parts of a bygone area. Certainly, a number of new services seem to be heading towards being "Internet communities" rather than using proprietary technology shifting their focus from providing content to providing Internet access. However, the large majority of residential users still use on-line services. On-line services not only provide access but also, technical customer support services, a basic menu of standard content, aggregated, averaged billing for a range of content and parental access control features.

Courtney Fields
October 28, 1996
.HTML/JAVA Team

WWW(known as the World Wide Web) is the most popular computer application on the Internet. This application allows the user to retreive text and connect them to servers located throughout the world. The Web contains three major components which are HTML, HTTP, and URLs.

HTML(Hypertext Markup Language) is a easy minimal formatting language. HTML can be both presentational and descriptive. Presentational markup systems defines how text can be rendered, while descriptive markup renders content according to the capablities of the screen resolution such as fonts, width, spacing, etc. HTML is generated from other capable systems, due to the fact that, the capabilities of HTML are limited. HTML has three hyperklinks which are wrapping text or an image in a tag, displaying the document in a news browser, and the IMG tag. Because HTML is in demand within the Internet, it has replaced many text systems.

Next, HTTP(Hypertext Transfer Protocol) is an application in which it is a client server protocol. This protocol has many advantages that servers on the Web can use. Because HTTP is a textual protocol, this simplifies the text for simple browers on the Internet. The textual representation of HTTP is the most noted feature of ftp(file transfer protocol). FTP gives HTTP the ability to define missing operations for different functions. Futhermore, HTTP is a more complex application than HTML, that will require an efficiency for the client and the server.

The final application discussed in this article is URLs and URNs. URLs(Universal resource locator) is a locator that designates objects within the World Wide Web. URNs(Universal resource name) is a identifier which name the physical location of an object. The difference between a URL and an URN is that URLs are considered to be temporary references until a more powerful device can be deployed. On the other hand, URNs leads the browser to their destination and give a listing of the location.

In conclusion, I feel that this particular article taught me there are many interesting Internet applications, which can continue the growth and success of the World Wide Web.

World Wide Web: Whence, Whither, What Next?

World Wide Web: Whence, Whither, What Next? by Henning Schulzrinne, speculates where the World Wide Web (WWW) might be improved and which directions it might take from a technical perspective. In the past five years, the WWW has become, next to electronic mail, the most popular Internet application. It has been a major contribution in turning the Internet into a household word. The WWW allows users to retrieve text and multimedia objects.

The main WWW protocol for data retrieval is Hypertext Transfer Protocol (HTTP) which is an application-level protocol that is used probably exclusively with the Transmission Control Protocol (TCP). HTTP is a client/server protocol where the client, a WWW browser, asks the server for some information via a GET request or transfers information to the server. The simple protocol has the advantage that clients and servers do not have to remember anything beyond the transfer of a single document. There are some efforts to replace HTTP with a binary, ASN.1-based version that supports pipelining of several objects. The extensions of HTTP will probably reach a large fraction of a revised protocol. Displacement of HTTP by a different protocol does not seem to happen soon.

Hypertext Markup Language (HTML) is the one media type all browses understand and is a simple document type of the Standardized Generalized Markup Language (SGML). HTML is easy to understand and can be generated by translators from other text formats as well as written by hand and because it contains the actual text rather than font glyphs, it can be translated to Braille or synthetic speech. Within the Internet, HTML is replacing a number of similar text systems like multipurpose Internet mail extensions. While there have been extensions of SGML to the presentation of continuous media, they appear complex, but still do not offer the full programming flexibility of a client-side programming and scripting language like Java.

Universal resource locators (Urns) are used to designate objects within the WWW and name the physical location of an object and universal resource names (URNs) identify without regard to location. URLs are in widespread use and consist of an identifier for the protocol, the network location, and a path name within the server. URLs were considered to be temporary artifacts until a more powerful naming mechanism could be launched. However, URLs seem to be experiencing longevity as e-mail addresses.

One of the factors that have caused the success of the WWW is its ability to attract providers and serve as a base for new applications. There seem to be two contradictory directions for WWW applications: the browser that can do everything and having every application have WWW capabilities. The latter makes it difficult to integrate data types. Browses are already incorporation mail tools, new readers, and primitive file system managers. Other mechanisms to integrate different applications are currently being created.

WWW stresses the Internet in that browsing has low latency requirements. The data transfers can be anything from a short burst for a small image to several tens of megabytes for a video or audio clip. For any of the more popular services, the WWW can only scale if information content is mirrored and cached. A mirror provides a complete copy of some server. Mirrors are trusted by the data source. Caches are placed between client and WWW server and have no direct trust relationship with the server.

The WWW model is currently rather limited: retrieve an object (text or audio) and render it. It is likely that future browses will cease to be display-only and allow editing and storing back documents. This would make them more competitive with other computer-supported cooperative work environments.

The integration of multimedia is currently very primitive. A video clip is transferred via HTTP and then played with buffering or from local temporary storage. Playing audio and video as it arrives from the network avoids waiting minutes for it to

```
<html>
<head>
<TITLE>A Simple HTML Example</TITLE>
</head>
<body>
<H1>HTML is Easy To Learn</H1>
<P>Welcome to the world of HTML.
This is the first paragraph.  While short it is
still a paragraph!</P>
<P>And this is the second paragraph.</P>
</body>
</html>
```

```
<H1>Level-one heading</H1> <P>Welcome to the world of HTML.  This is the
first paragraph.  While short it is still a
paragraph!  </P> <P>And this is the second paragraph.</P>

<P ALIGN=CENTER>
This is a centered pargraph.  [See the formatted version below.]
</P>

<UL>
<LI> apples
<LI> bananas
<LI> grapefruit
</UL>

<OL>
<LI> oranges
<LI> peaches
<LI> grapes
</OL>

<DL>
<DT> NCSA
<DD> NCSA, the National Center of Supercomputing Applications,
     is located on the campus of the Universtiy of Illinois
     at Urbana-Champaign.
<DT> Cornell Theory Center
<DD> CTC is located on the campus of Cornell University in Ithaca,
     New York.
</DL>

<DL COMPACT>
<DT> -i
<DD>invokes NCSA Mosaic for Microsoft Windows using the
initialization file defined in the path
<DT> -k
<DD>invokes NCSA Mosaic for Microsoft Windows in kiosk mode
</DL>

<UL>
<LI> A few New England states:
   <UL>
   <LI> Vermont
   <LI> New Hampshire
   <LI> Maine
   </UL>
<LI> Two Midwestern states:
   <UL>
   <LI> Michigan
   <LI> Indiana
   </UL>
</UL>

</E>
```

```
#!/bin/csh
cd $SCR
cfs get mysrc.f:mycfsdir/mysrc.f
cfs get myinfile:mycfsdir/myinfile
fc -02 -o mya.out mysrc.f
mya.out
cfs save myoutfile:mycfsdir/myoutfile
rm *
</PRE>

<BLOCKQUOTE>
<P>Omit needless words.</P>
<P>Vigorous writing is concise.  A sentence should contain no
unnecessary words, a paragraph no unnecessary sentences, for the
the same reason that a drawing should have no unnecessary lines and a
machine no unnecessary parts.</P>
--William Strunk, Jr., 1918
</BLOCKQUOTE>

<ADDRESS>
A Beginner's Guide to HTML / NCSA / pub@ncsa.uiuc.edu / revised April 96
</ADDRESS>

National Center for Supercomputing Applications<BR>
605 East Springfield Avenue<BR>
Champaign, Illinois 61820-5518<BR>

<HR SIZE=4 WIDTH=50%>

<A HREF="MaineStats.html">Maine</A>

<A HREF="AtlanticStates/NYStats.html">New York</A>

<A HREF="../US.html">United States</A>

documentA.html;

In addition to the many state parks, Maine is also home to
<a href="MaineStats.html#ANP">Acadia National Park</a>

<H2><A NAME="ANP">Acadia National Park</a></H2>

...More information about <A HREF="#ANP">Acadia National Park</a>
is available elsewhere in this document.

<A HREF="mailto:emailinfo@host">Name</a>

<A HREF="mailto:pubs@ncsa.uiuc.edu">NCSA Publications Group</a>

<IMG SRC=ImageName>

<IMG SRC=SelfPotrait.gif HEIGHT=100 WIDTH=65>

<p ALIGN=CENTER>
<IMG SRC = "BarHotlist.gif">
</p>

<BODY BACKGROUND="filename.gif">

<BODY BGCOLOR=#000000" TEXT="#FFFFFF" LINK=#9690CC">

<A HREF="MyImage.gif">link anchor</A>

<A HREF="LargerImage.gif"><IMG SRC="SmallImage.gif"></A>
```

Mathematics and Computer Science Department

"Pictures of Lester Hall"

About the Department

Department Faculty and Staff

- Dr. Sohindar Sachdev, Department Chair
- William Barker
- George Coleman
- Dr. Stephen Nemecek
- Dr. Kossi Edoh
- Dr. Linda Hayden
- Dr. Johnny Houston
- Dr. Krishna Kulkarni
- Georgia Lawrence
- Vindod Manglik
- Dr. Muhammad Mannan
- Ralph Okojie
- Vadim Raskin
- Dr. Jharna Sengupta
- Dr. Dipendra Sengupta
- Dore Subrao

Funded Research Projects

- ONR - Nurturing ECSU Research Talent

  Student Research Teams

  - ATM
  - Fractals and Chaos
  - HTML/JAVA
  - Statistics
  - Visualization

- NASA - Network Resources and Training Site

Upcoming Events

- Conferences
- Training

Mathematics and Computer Science Club

About ECSU	Admissions Information	Academics & Research	The Library

Athletics	Administrative Services	Alumni, Development & Planning

About the Department

The Department of Mathematics and Computer Science offers B.S. degree programs in Mathematics, Applied Mathematics and Computer and Information Sciences. Students who are planning to teach high school and/or middle school mathematics should minor in Secondary and/or Middle Grades Education.

The Department also offers minors in mathematics, computer science, statistics, applied mathematics and airway science. The airway science minor prepares students for careers in aviation as air traffic controllers, aviation service managers, computer researchers and other aviation oriented professions in government and private industry. Also, the Department offers a second major option in Mathematics for Education Majors who are required to have a second major.

The Department offers general education courses in College Algebra and Pre-calculus. It also provides students with experiences, knowledge and skills in Mathematics, Applied Mathematics, Statistics and Computer and Information Sciences with courses above the General Education Core.

The Department has designed its curriculum to achieve the following objectives:

- To develop in all students proficiency in mathematical thinking and reasoning;
- To assist all students in developing computer literacy including skills needed to use a microcomputer and computer software;
- To prepare students who major in mathematics and minor in Secondary and/or Middle Grades Education to teach mathematics in the public and private schools:
- To prepare students who major in mathematics, applied mathematics or computer and information sciences for entry level positions in industry; multinational corporations, scientific establishments, and federal, state, and local governments; and
- To prepare students for graduate studies in mathematics, statistics, applied mathematics, computer and information sciences, and mathematics education.

Students majoring in Computer Science or Mathematics have numerous career opportunities available to them as system analysts, programmers, system designers, system administrators, mathematicians, statisticians and high and/or middle school mathematics teachers. It is strongly recommended that prospective students contact the office of the Department of Mathematics and Computer Sciences as soon as possible. It is best to begin planning early so that courses can be taken in the proper sequence.

Computer Science Course Descriptions

Computer Science Suggested Curriculum

Mathematics Course Descriptions

Mathematics Suggested Curriculum

Airway Science Course Descriptions

Airway Science Suggested Curriculum

Back to Math & Computer Science Main Menu

Chairman of the Mathematics and Computer Science Department

Elizabeth City State University

Elizabeth City, NC 27909

Vita

Sohindar S. Sachdev

- Educational Qualifications
- Teaching/Educational Experience
- Books Published in India
- Professional Membership
- Papers Presented(Selected)
- Funded Projects
- Publications
- Unpublished Work

You can E-Mail me at sachdess@alpha.ecsu.edu

Back to Math & Computer Science Main Menu

Fractals/Chaos Team Report

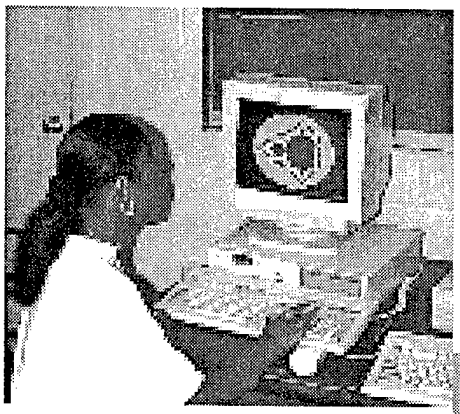
Fractals and Chaos

Most naturally occuring processes are inherently nonlinear and can give rise to very complex behaviors. Even very simple mathematical models can exhibit behavior that give rise to extremely convoluted (and often very beautiful) fractal shapes. The discovery of this fundamentally new area of mathematics has been crucially dependent on computational intensive graphic methods and has given birth to a radically new paradigm for mathematical research: experimental research.

In this project we will perform experimental mathematical investigation. The mathematical contents will comprisefractals, nonlinear dynamics and mathematical chaos.

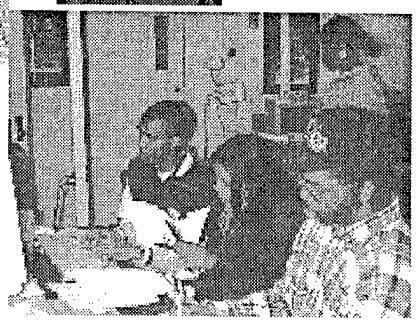
We will study the orbits of a family of quadratic dynamical systems and investigate the period doubling route to chaos. We will design and develop mathematical materials and Mathematica programs necessary to do the investigation.

We will apply fundamental mathematical concepts to a wide variety of physical, biological and social processes (e.g., population growth, measles problem, growth of plant, problems of epidemiology, and the economics of arms race). The deep connection between geometry and nonlinear dynmaics will be explored and computer programs will be developed to generate fractal maps and pictures of compelling beauty. Finally, through guided work in experimental mathematics students will acquire a deeper understanding of mathematical and scientific thinking.



Fractals/Chaos Team Members

Dr. D. Sengupta
Team Mentor



Experimental Research in Fractal and Chaos using Mathematica

Corey Ellis (cellis@umfort.cs.ecsu.edu)
Tammara Ward (Tward@umfort.cs.ecsu.edu)
Brian Jordan (Bjordan@umfort.cs.ecsu.edu)

Department of Mathematics & Computer Science

Elizabeth City State University

Elizabeth City, NC 27909

U. S. A.

Introduction:

One of today's most exciting areas of mathematics is the study of dynamical systems. There are numerous unsolved problems and the field is extremely active. Not only mathematicians, but also ecologists, chemists, economists, and physicists have become involved in the field. The theory of dynamical systems is used in computer graphics, population models, and meteorology, to name a few. Many mathematicians feel that some knowledge of the subject is imperative. A leading biologist Robert M. May wrote as early as 1976: *I would therefore urge that people be introduced to, say, the Velhurst equation, early in their mathematical education. This equation can be studied phenomenologically by iterating it on a calculator, or even by hand. Its study does not involve as much conceptual sophistication as does elementary calculus. Such study would greatly enrich the student's intuition about non-linear systems. Not only in research, but also in everyday world of politics and economics, we would all be better off if more people realized that simple non-linear systems do not necessarily possess simple dynamical properties.*

At Elizabeth City State University, the Fractal and Chaos research team performed mathematical investigation on the Velhurst Population model. We investigated this model

discretely and from the continuous perspective. Our approach was to compare each model with actual population data. From this experimentation, we will make a conjecture as too see which model best describes the population.

Definition:

A discrete dynamical system is a rule $p_{n+1} = f(p_n)$ that can be used to generate each term of a sequence from the preceding term.

The discrete dynamical system that was studied is the **Verhulst Population Model:**

$$p_{n+1} = p_n + k p_n (1 - p_n)$$

Definition:

Equilibrium point or fixed point in a discrete dynamical system is the solution of the equation $p = f(p)$.

The fixed points for the Verhulst Model are 0 and 1.

Definition:

An Orbit is the path of a sequence as it approaches the limit L. When studying the orbit of a particular sequence in a dynamical system: the question is "What happens to the orbit over a period of time?"

Discrete Case:

While studying the Verhulst population model using a Mathematica Iterator program (Appendix I). The question to be solved was "What values of k and initial values of p_0, $0 < p_0 < 1$, does the orbit of the discrete dynamical system

$$p_{n+1} = p_n + k\, p_n (1 - p_n)$$

is

a) simple (converge to 1)
b) interesting (neither simple nor dangerous)
c) dangerous (when the values get larger and larger beyond the computer capacity)

By experimentation we found that the orbits are simple when $0 < k <= 2$, interesting when $2 < k <= 2.57$ (this includes 2-cycles , 4-cycles , 8-cycles, etc), chaotic when $2.57 < k <= 3$. and dangerous when $k > 3$. The bifurcation diagram that describes this behavior graphically was captured (Appendix II). Also the orbits of the dynamical system were graphed (Appendix III - IX).

70 Noticed how the orbits tend to either converge to one or oscillate above and below one. The fixed point one is representing the maximum the population can be at any given time. The oscillation is representing the various cycles (2-cycles , 4-cycles , 8-cycles, etc) ; this can be translated into the up and down of the population (life and death).

Continuous Case:

They were two different population models that we studied for the continuous case. The first was the **Malthus population model**; this model of population growth is based on the assumption that the rate of growth of the population is proportional to the size of the population.

The rate of growth of the population is the derivative dP/dt. Being proportional to the population is expressed as the product kP, of the population p and the proportionality constant k.

Hence the assumption is expressed as a differential equation

$$dP/dT = k\, P$$

where

t = time (independent variable)
p = population (dependent variable)
k = proportionality constant between the rate of growth of the population and the size of the population or "Growth-Rate Coefficient"

In order to see how valid this model was we were given a U. S. Census figure Funk and Wagnalls 1994 World Almanac from 1790 - 1990. We wanted to find out how well the Malthus model fits with the actual U. S. population. In order to begin we had to first solve the differential equation for P.

Derivation:

$$dp/dt = k\, p$$

$$\ln p + c_1 = kt + c_2 - c_1 = c$$

$$e^{\ln p} = e^{k t} + e^{c}$$

$$p = e^{(k t + c)}$$

$$p = p_0\, e^{k t} \quad , \; p_0 = e^{c}$$

then solve for k

$$p(t)/p_0 = e^{k t}$$

$$\ln (p(t)/p_0) = k t$$

$$k = \ln (p(t)/p_0)/t$$

Next, we took the values of the census, and plug them into the model, and tryed to see how close the values were to the actual population at that year (Appendix X). Using Mathematica, we found out the model of $p(t)$ does an excellent job of predicting the population until roughly 1860, after 1860 the prediction is much too large (Appendix III). We concluded, that the model is valid when population is very small.

However , as time continues , the model predicts that the population will continue to grow without any limits, but realistically we know this to be ridiculous. Now we turn to the second model to see if adding a capacity restriction will account for the fact that population exists in a finite amount of space and with limited resources and a limited environment.

The second model studied was the **Verhulst population model**; we add the assumptions:

1) If the population is small, the rate of growth of the population is proportional to its size
2) If the population is too large to be supported by its environment and resources, the population will decrease. That is , the rate of growth is negative.

Our assumption about limited resources introduces another quantity, the size of the population that corresponds to being "too large". The quantity is the second parameter by m, that we call the maximum supportable population in "carrying capacity" of the environment. In terms of the maximum supportable capacity population, we assume that $p(t)$ is increasing if $p(t) < m$. However, if $p(t) > m$, we can restate our assumption as :

$$dp/dt = k\,p$$

if p is small (first assumption).

if $p > m$, then

$$dp/dt < 0$$

(second assumption).

Modify the exponential model as little as possible. we want to look for an expression of the form

$$dp/dt = k\ (\ something\ )\ p$$

we want this 'something' factor to be close to 1 if p is small , but if $p > 0$ we want 'something' to be negative. The simplest expression that has these properties is

$$something = (\ 1 - p/m\ )$$

Thus our model is

$$dp/dt = k\ (\ 1 - p/m\ )\ p$$

$$= k/m\ (\ m-p)\ p$$

$$= k\ (\ m-p\ )\ p$$

$$= k\ (\ m-p\ )\ p$$

$$p = k/m$$

Hence the assumption is expressed as a differential equation

$$dp/dt = k\ (\ m - p\ )\ p$$

where

t = time
p = population
k = growth rate
m = maximum supportable population

Using the Funk and Wagnalls Census from 1790 to 1990 we again look at the validity of this model in comparison to the population. We want to see if adding a constraint or maximum to the model will cause the model to follow the population trend of the Funk and Wagnalls census better than the Malthus model.

Derivation:

First , solve for p

$$dp/dt = k\,p\,(m - p)$$

$$dp/p(m - p) = k\,dt$$

$$A/p + B/(m - p) = 1/p\,(m - p) \qquad \text{'Partial Fraction method'}$$

$$A\,(m - p) + B\,(p) = 1$$

$$p = m \qquad p = 0$$
$$B = 1/m \qquad A = 1/m$$

Integrate:

$$1/m\,[\,1/p + 1/m-p\,] = k\,dt$$

$$1/m\,(\ln p - \ln|m - p|) = k\,t + c$$

$$1/m * \ln p/(m - p) = k\,t + c$$

$$t = 0 \qquad p = p_o$$

$$1/m * \ln p_o/(m - p_o) = c$$

$$1/m * \ln p/(m - p) = k\,t + 1/m * \ln p_o/(m - p_o)$$

$$\ln p/(m - p) = m\,k\,t + \ln p_o/(m - p_o)$$

$$\ln p/(m - p) - \ln p_o/(m - p_o) = m\,k\,t$$

$$\ln (p/m-p * m - p_o/p_o) = m\,k\,t$$

$$(m - p_o) * p/p_o(m - p) = e^{m\,k\,t}$$

$$p = p_o\,m/[(m - p_o)\,e^{-m\,k\,t}]$$

Next , solve for k

$$p = p_o\,m/(m - p_o)\,e^{-m\,k\,t}$$

$$p(t) = p_o\,m/(m - p_o)\,e^{-m\,k\,t}$$

$$[\,p_o + (m - p_o)\,e^{-m\,k\,t}\,]\,p(t) = p_o\,m$$

$$p_o + (m - p_o)\,e^{-m\,k\,t} = p_o\,m/p(t)$$

$$(m - p_o)\,e^{-m\,k\,t} = p_o\,m/p(t) - p_o$$

$$e^{-m\,k\,t} = p_o\,m/(m - p)\,p(t) - p_o/(m - p_o)$$

$$\ln(e^{-m\,k\,t}) = \ln[\,p_o\,m/(m - p)\,p(t) - p_o/(m - p_o)]$$

$$-m\,k\,t = \ln[\,p_o\,m/(m - p)\,p(t) - p_o/(m - p_o)]$$

$$k = \ln[(p_o\,m/(m - p)\,p(t)) - (p_o/(m - p_o))]/-m\,t$$

Now we solve for m (maximum value)

$$dp/dt = k\,(m-p)\,p$$

$$d^2p/dt^2 = k\,dp/dt\,(m-p) - k\,dp/dt\,p$$

$$= k\,dp/dt\,m - 2\,k\,p\,dp/dt$$

$$= dp/dt\,(k\,m - 2\,k\,p)$$

$$= dp/dt\,k\,(m - 2\,p)$$

Now look at

$$(m - 2p) = 0$$

$$m = 2 p$$

We found that the maximum will be double the population. In order to find what the maximum population will be for the census (data) we used we needed to find what years had the greatest actual margin in between the population (Appendix XI). We found out that in between 1950 and 1960 the margin was greatest. The population was 179 million. Next we take that population in 1960 and double it. By doubling this population (358 million) we assume that this will be our maximum population.

Finally, we plug values from the census into the population model, and we analyze how effective the Verhulst model was in comparison to the Malthus model. We concluded that the second model followed the Funk and Wagnalls census extremely well compared to the Malthus model

(Appendix IV). Graphically the model coincides with the population census up certain year (Appendix IV), and Algebraically the model tends to follow the census (Appendix XI).

In Our study so far we have assumed that $p(t)$ is a continuing function of time variable t. In reality, we know that population does not change continuously but rather in discrete amounts at discrete times.

Rescaling:

For our convenience we now rescale our population measurements to represent fractions of the maximum supportable population. Thus, we introduce a new dependent variable P, which is defined in terms of population p by

$$P = p/m$$

This has the effect of making the maximum supportable population equivalent to one unit of population. The new dependent variable P takes only values between 0 and 1. Using the above scaling, the differential equation changes to

$$dp/dt = K P (1 - P)$$

where

$$k = K M$$

and the solution becomes

$$P = P_0 / (1 - p_0) e^{-kt} + P_0$$

If times are measured in discrete steps dt , then the corresponding discrete model is

$$dp/dt = k p (1-p)$$

For our convenience assume $dt = 1$

Then we write

$$dp = P_{n+1} - P_n$$

and rewrite the above equation

$$P_{n+1} - P_n = k P_n (1-P_n)$$

$$P_{n+1} = P_n + k P_n (1-P_n) \quad \text{for n} = 0,1,2...$$

Discrete vs Continuous:

The question after researching the discrete case and the continuous case was "Which case

(continuous or discrete) better relates to the overall picture of the actual population. In order to compare the two cases values needed to be taken for k and p_o.

For the choices of k = 0.5 , 1.5 , 2.2 , 2.5 , 2.9 with p_o = 0.2 we compared the graphical solution of discrete and continuous model using Mathematica.

For k = 2.2, they notice something peculiar. The discrete sequence does not close to any number; instead, within only few iterations, it starts to oscillate back and forth. This limiting behavior is called a cycle of period 2, or simply a 2-cycle. As k increases to 2.5 the iteration settles into an even more complicated pattern, a cycle of period 4. For k = 3.9, the sequence exhibits no discernible pattern. The values of p seem to jump around at random (Appendix VII - IX).

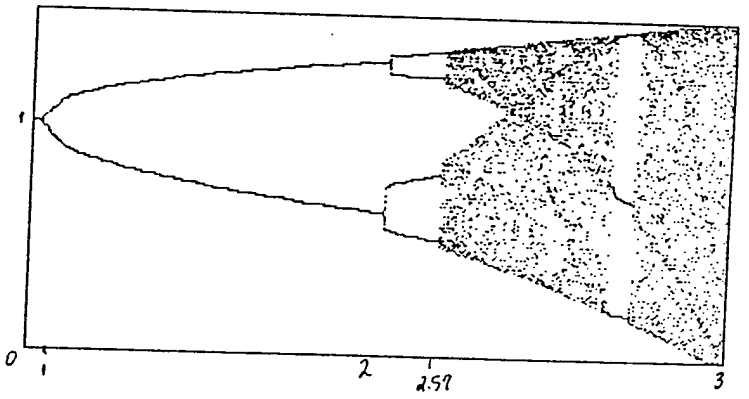
From studying Appendix VII - IX one can see the groups of the discrete and continuous models together. The continuous case seems to converge to one (maximum capacity of the population at any given time) and that is it . The continuous case does not exhibit the fluctuation of the population (life and death), but the discrete case from the graphical analysis shows fluctuation about the fixed point one (maximum capacity of the population at any given time). This oscillation or fluctuation can be considered mathematically to be a cycle of some type, but realistically this oscillation could very well be the representation of people being born and people dying throughout the whole population. The discrete case and continuous case tells us that the population can never reach its maximum which makes sense because people are constantly being born and dying everyday. Noticing all of the characteristics that the discrete case shows it is evident that this model best describes population in realistic terms.

References

1. Devaney, R. *An Introduction to Chaotic Dynamical Systems, 2nd edition, Addison - Wesley, 1989.*
2. Holmgren , R. *A First Course in Discrete Dynamical Systems, Springer - Verlag, 1994.*
3. Peitgen , H and Richter, P. *The Beauty of Fractals, Springer - Verlag, 1986.*
4. Wattenberg, F. *Calculus in a Real and Complex World, PWS - Kent Publishing Co., 1992.*

```
Clear[h];
h[x_]:= x + 3.1 x (1-x);
StartingValues= .1;
FirstIteration= 150;
LastIteration= 200;
i= 150;
y= N[StartingValues];
While[i<= LastIteration,
      if[i>= FirstIteration,Print[i," ",N[y,8]]];
      y= h[y];
      i= i+1]
```

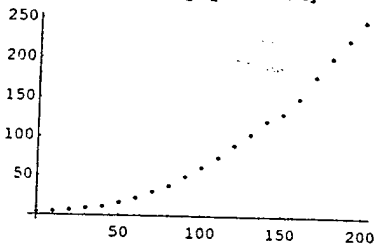

Bifurcation Diagram



```
uspopulation=Table[{{0,3.9},{10,5.3},{20,7.2},
                    {30,9.6},{40,12},{50,17},
                    {60,23},{70,31},{80,38},
                    {90,50},{100,62},{110,75},
                    {120,91},{130,105},{140,122},
                    {150,131},{160,151},{170,179},
                    {180,203},{190,226},{200,249}}]
```

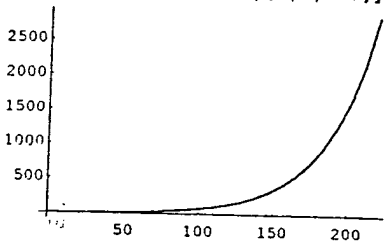
```
{{0, 3.9}, {10, 5.3}, {20, 7.2}, {30, 9.6}, {40, 12},
 {50, 17}, {60, 23}, {70, 31}, {80, 38}, {90, 50},
 {100, 62}, {110, 75}, {120, 91}, {130, 105},
 {140, 122}, {150, 131}, {160, 151}, {170, 179},
 {180, 203}, {190, 226}, {200, 249}}
```

```
pointplot= ListPlot[uspopulation]
```

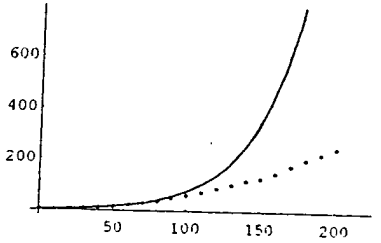



```
-Graphics-
```

```
Malthus=Plot[3.9*Exp[.03 t],{t,0,220}]
```




```
Show[Malthus, pointplot]
```

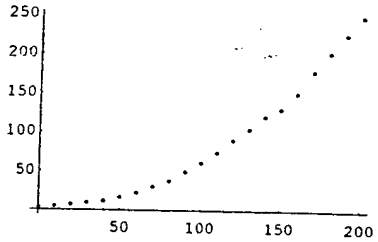



```
-Graphics-
```

```
uspopulation=Table[{{0,3.9},{10,5.3},{20,7.2},
                    {30,9.6},{40,12},{50,17},
                    {60,23},{70,31},{80,38},
                    {90,50},{100,62},{110,75},
                    {120,91},{130,105},{140,122},
                    {150,131},{160,151},{170,179},
                    {180,203},{190,226},{200,249}}]
```

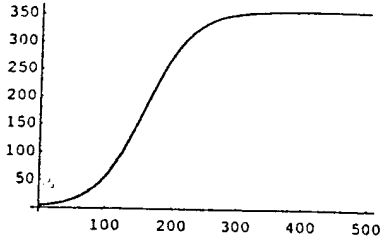
```
{{0, 3.9}, {10, 5.3}, {20, 7.2}, {30, 9.6}, {40, 12},
 {50, 17}, {60, 23}, {70, 31}, {80, 38}, {90, 50},
 {100, 62}, {110, 75}, {120, 91}, {130, 105},
 {140, 122}, {150, 131}, {160, 151}, {170, 179},
 {180, 203}, {190, 226}, {200, 249}}
```

```
pointplot= ListPlot[uspopulation]
```



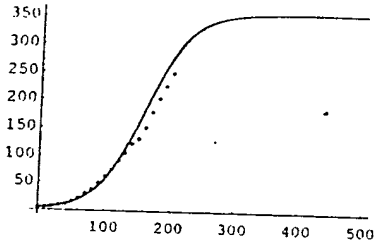
-Graphics-

```
Verhulst=Plot[(3.9*358)/((358-3.9)*Exp[-358*.00008*t]+3.9),
{t,0,500}]
```



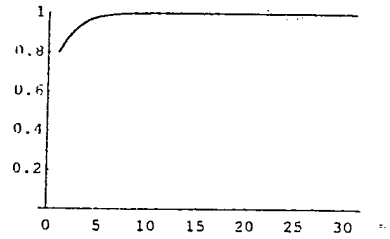
-Graphics-


```
Show[Verhulst, pointplot]
```

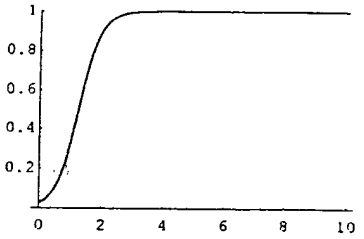


-Graphics-

```
f[x_] := x+.5*x*(1-x)

iteration=NestList[f, .8, 30]

{0.8, 0.88, 0.9328, 0.964142, 0.981428, 0.990542,
  0.995226, 0.997602, 0.998798, 0.999398, 0.999699,
  0.999849, 0.999925, 0.999962, 0.999981, 0.999991,
  0.999995, 0.999998, 0.999999, 0.999999, 1., 1.,
  1., 1., 1., 1., 1., 1., 1., 1., 1.}

discretepoint=Table[iteration]

{0.8, 0.88, 0.9328, 0.964142, 0.981428, 0.990542,
  0.995226, 0.997602, 0.998798, 0.999398, 0.999699,
  0.999849, 0.999925, 0.999962, 0.999981, 0.999991,
  0.999995, 0.999998, 0.999999, 0.999999, 1., 1.,
  1., 1., 1., 1., 1., 1., 1., 1., 1.}

joinedplot1=ListPlot[discretepoint, PlotJoined -> True
, PlotRange -> {0,1}]
```



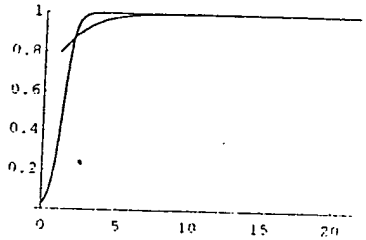

```
-Graphics-

continuepic=Plot[p[t], {t, 0, 10}, PlotRange -> {0,1}]
```




```
-Graphics-
```

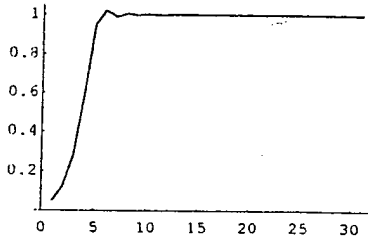


```
Show[continuepic, joinedplot1, PlotRange -> {0,1}]
```



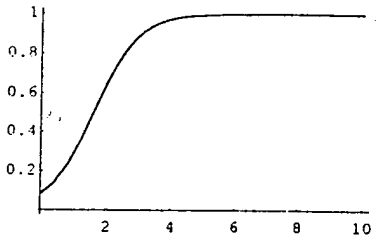

```
-Graphics-
```

```
f[x_] := x+1.5*x*(1-x)
iteration=NestList[f, .05, 30]
{0.05, 0.12125, 0.281073, 0.584179, 0.94855,
  1.02175, 0.988413, 1.00559, 0.997157, 1.00141,
  0.999292, 1.00035, 0.999823, 1.00009, 0.999956,
  1.00002, 0.999989, 1.00001, 0.999997, 1.,
  0.999999, 1., 1., 1., 1., 1., 1., 1., 1., 1., 1.}
discretepoint=Table[iteration]
{0.05, 0.12125, 0.281073, 0.584179, 0.94855,
  1.02175, 0.988413, 1.00559, 0.997157, 1.00141,
  0.999292, 1.00035, 0.999823, 1.00009, 0.999956,
  1.00002, 0.999989, 1.00001, 0.999997, 1.,
  0.999999, 1., 1., 1., 1., 1., 1., 1., 1., 1., 1.}
joinedplot2=ListPlot[discretepoint, PlotJoined -> True,
PlotRange -> {0,1.05}]
```



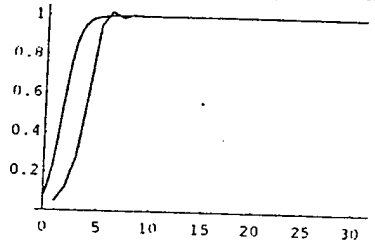
-Graphics-

```
p[t_] := .083/(.917*Exp[-1.5*t]+.083)
continuepic=Plot[p[t], {t, 0, 10}]
```



-Graphics-


```
Show[joinedplot2, continuepic, PlotRange -> {0,1.05}]
```

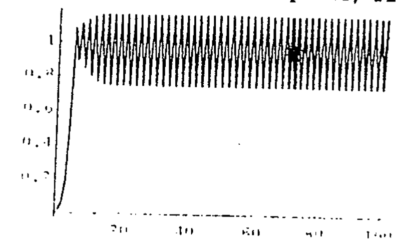


-Graphics-

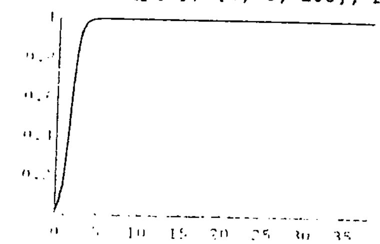
```
f[x_] := x+2.2*x*(1-x)
iteration=NestList[f, .02, 100]
{0.02, 0.06312, 0.193219, 0.536167, 1.08329,
 0.884792, 1.10905, 0.842979, 1.13418, 0.799369,
 1.1522, 0.766395, 1.16027, 0.751168, 1.16238,
 0.747136, 1.16277, 0.746392, 1.16283, 0.74627,
 1.16284, 0.74625, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284}
discretepoint=Table[iteration]
{0.02, 0.06312, 0.193219, 0.536167, 1.08329,
 0.884792, 1.10905, 0.842979, 1.13418, 0.799369,
 1.1522, 0.766395, 1.16027, 0.751168, 1.16238,
 0.747136, 1.16277, 0.746392, 1.16283, 0.74627,
 1.16284, 0.74625, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746247,
 1.16284, 0.746247, 1.16284, 0.746247, 1.16284,
 0.746247, 1.16284, 0.746247, 1.16284, 0.746217,
 1.16284}
```



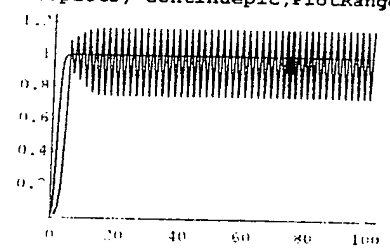
```
joinedplot3=ListPlot[discretepoint, PlotJoined -> True]
```




```
-Graphics-
p[t_] := .029/(.971*Exp[-2.2*t]+.029)
continuepic= Plot[p[t], {t, 0, 100}, PlotRange -> {0,1}]
```




```
-Graphics-
Show[joinedplot3, continuepic,PlotRange -> {0,1.25}]
```




```
-Graphics-
```

```
f[x_] :=x+2.1*x*(1-x)
iteration= NestList[f, .02, 100]
```

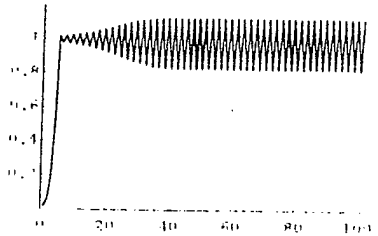
```
{0.02, 0.06116, 0.181741, 0.494034, 1.01896,
  0.97839, 1.02279, 0.97384, 1.02734, 0.968357,
  1.0327, 0.961779, 1.03898, 0.953937, 1.04621,
  0.94468, 1.05443, 0.933912, 1.06352, 0.921648,
  1.07329, 0.908094, 1.08336, 0.893714, 1.09319,
  0.879251, 1.10221, 0.865638, 1.10989, 0.853767,
  1.11595, 0.844222, 1.1204, 0.837125, 1.12345,
  0.832196, 1.12545, 0.828952, 1.12671, 0.826899,
  1.12749, 0.825634, 1.12796, 0.824867, 1.12824,
  0.824407, 1.1284, 0.824133, 1.1285, 0.82397,
  1.12856, 0.823874, 1.1286, 0.823817, 1.12862,
  0.823784, 1.12863, 0.823764, 1.12864, 0.823752,
  1.12864, 0.823745, 1.12864, 0.823741, 1.12864,
  0.823739, 1.12864, 0.823737, 1.12865, 0.823736,
  1.12865, 0.823736, 1.12865, 0.823736, 1.12865,
  0.823735, 1.12865, 0.823735, 1.12865, 0.823735,
  1.12865, 0.823735, 1.12865, 0.823735, 1.12865,
  0.823735, 1.12865, 0.823735, 1.12865, 0.823735,
  1.12865, 0.823735, 1.12865, 0.823735, 1.12865,
  0.823735, 1.12865, 0.823735, 1.12865, 0.823735,
  1.12865}
```

```
discretepoint= Table[iteration]
```

```
{0.02, 0.06116, 0.181741, 0.494034, 1.01896,
  0.97839, 1.02279, 0.97384, 1.02734, 0.968357,
  1.0327, 0.961779, 1.03898, 0.953937, 1.04621,
  0.94468, 1.05443, 0.933912, 1.06352, 0.921648,
  1.07329, 0.908094, 1.08336, 0.893714, 1.09319,
  0.879251, 1.10221, 0.865638, 1.10989, 0.853767,
  1.11595, 0.844222, 1.1204, 0.837125, 1.12345,
  0.832196, 1.12545, 0.828952, 1.12671, 0.826899,
  1.12749, 0.825634, 1.12796, 0.824867, 1.12824,
  0.824407, 1.1284, 0.824133, 1.1285, 0.82397,
  1.12856, 0.823874, 1.1286, 0.823817, 1.12862,
  0.823784, 1.12863, 0.823764, 1.12864, 0.823752,
  1.12864, 0.823745, 1.12864, 0.823741, 1.12864,
  0.823739, 1.12864, 0.823737, 1.12865, 0.823736,
  1.12865, 0.823736, 1.12865, 0.823736, 1.12865,
  0.823735, 1.12865, 0.823735, 1.12865, 0.823735,
  1.12865, 0.823735, 1.12865, 0.823735, 1.12865,
  0.823735, 1.12865, 0.823735, 1.12865, 0.823735,
  1.12865}
```

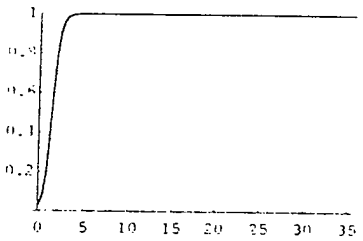


```
discretepic= ListPlot[discretepoint,PlotJoined -> True
, PlotRange -> {0,1.2}]
```



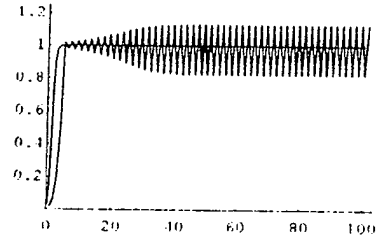
-Graphics-

```
p[t_] := .028/(.972*Exp[-2.5*t]+ .028)
continuepic= Plot[p[t], {t, 0, 100}, PlotRange -> {0,1}]
```



-Graphics-

```
Show[discretepic, continuepic, PlotRange -> {0,1.25}]
```



-Graphics-

```
f[x_] := x+2.9*x*(1-x)
iteration= NestList[f, .02, 100]
```

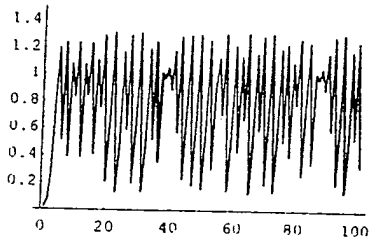
```
{0.02, 0.07684, 0.282553, 0.870432, 1.19749,
 0.51165, 1.23626, 0.389243, 1.07867, 0.832585,
 1.23681, 0.387438, 1.07569, 0.839566, 1.23018,
 0.409005, 1.10999, 0.75593, 1.29098, 0.201598,
 0.668372, 1.31116, 0.128018, 0.451744, 1.16999,
 0.593217, 1.29302, 0.194274, 0.648215, 1.30951,
 0.134126, 0.470921, 1.19347, 0.52386, 1.24721,
 0.353076, 1.01547, 0.969903, 1.05456, 0.88771,
 1.17678, 0.573477, 1.28282, 0.230678, 0.745329,
 1.29579, 0.184277, 0.620203, 1.3033, 0.156951,
 0.540672, 1.26087, 0.306977, 0.92393, 1.12775,
 0.709941, 1.30712, 0.142926, 0.49817, 1.22316,
 0.431575, 1.143, 0.669004, 1.31117, 0.127968,
 0.451584, 1.16979, 0.593807, 1.29329, 0.193302,
 0.645517, 1.30911, 0.135603, 0.475526, 1.19879,
 0.507702, 1.23253, 0.401391, 1.09819, 0.785476,
 1.27414, 0.261204, 0.820836, 1.24732, 0.352701,
 1.01478, 0.971286, 1.05216, 0.892996, 1.1701,
 0.592891, 1.29287, 0.194813, 0.649711, 1.30971,
 0.133374, 0.468572, 1.19071, 0.532184, 1.25418,
 0.329695}
```

```
discretepoint= Table[iteration]
```

```
{0.02, 0.07684, 0.282553, 0.870432, 1.19749,
 0.51165, 1.23626, 0.389243, 1.07867, 0.832585,
 1.23681, 0.387438, 1.07569, 0.839566, 1.23018,
 0.409005, 1.10999, 0.75593, 1.29098, 0.201598,
 0.668372, 1.31116, 0.128018, 0.451744, 1.16999,
 0.593217, 1.29302, 0.194274, 0.648215, 1.30951,
 0.134126, 0.470921, 1.19347, 0.52386, 1.24721,
 0.353076, 1.01547, 0.969903, 1.05456, 0.88771,
 1.17678, 0.573477, 1.28282, 0.230678, 0.745329,
 1.29579, 0.184277, 0.620203, 1.3033, 0.156951,
 0.540672, 1.26087, 0.306977, 0.92393, 1.12775,
 0.709941, 1.30712, 0.142926, 0.49817, 1.22316,
 0.431575, 1.143, 0.669004, 1.31117, 0.127968,
 0.451584, 1.16979, 0.593807, 1.29329, 0.193302,
 0.645517, 1.30911, 0.135603, 0.475526, 1.19879,
 0.507702, 1.23253, 0.401391, 1.09819, 0.785476,
 1.27414, 0.261204, 0.820836, 1.24732, 0.352701,
 1.01478, 0.971286, 1.05216, 0.892996, 1.1701,
 0.592891, 1.29287, 0.194813, 0.649711, 1.30971,
 0.133374, 0.468572, 1.19071, 0.532184, 1.25418,
 0.329695}
```

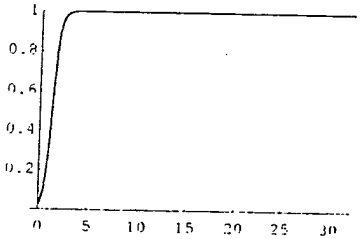


```
joinedplot4= ListPlot[discretepoint, PlotJoined -> True
,PlotRange -> {0,1.5}]
```



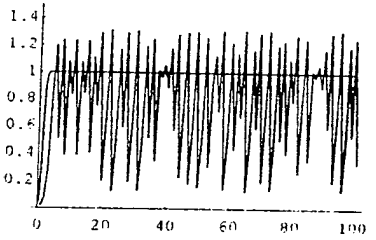
-Graphics-

```
p[t_] := .027/(.973*Exp[-2.9*t]+.027)
continuepic= Plot[p[t], {t, 0, 100}, PlotRange -> {0,1}]
```



-Graphics-

```
Show[joinedplot4, continuepic, PlotRange -> {0,1.5}]
```



-Graphics-

Fractals

A fractal is a graphical representation of an equation. In a fractal the whole image is consisting of smaller copies of the whole. This is like a repeating pattern to form the whole image. In a fractal the area of one space is decreasing to form the new area of space for the image to be represented. Examples of two types of fractals using a repeating pattern and area will be discussed in Sierpinski's Triangle and the Tree fractal.

Sierpinski-Triangle and Its Variations

The fractal Sierpinski-Triangle is an older fractal, introduced in 1916 by a Polish mathematician **Waclaw Sierpinski (1882-1969)**. If in Sierpinski's-Triangle a person were to take a part of the triangle and magnify it, he or she would find that it is an exact replicate of the larger triangle. If a person were to continue to do so they would find that the image of the larger triangle remains the same continuously unto infinity. This process of replication is **recurrence.**

Construction

The construction of the Sierpinski Triangle is quite simple, consider an equilateral triangle for the initial polygon. Let the iterative be to:

a)Connect the midpoints of the sides with line segments.

b)Remove the middle triangle of the four triangles formed.

At the first stage, three equilateral triangles replace the initial one. At the second stage, the rule is applied to each of these three triangles, subdividing each one into three smaller similar triangles.

The iterative process requires that the rule be applied repeatedly on all remaining equilateral triangles at each and every stage, once the middle triangles are removed. It is important to notice that as the number of triangles increases the area of the original triangle decreases. The process of using the midpoints to find new vertices for the triangle continue to infinity. The final result is generated by infinite iterations of the steps described; it is called Seirpinski's triangle.

Predicting Area and Number of Triangles Produced

Using the stages and images produced by using the midpoint method, a person can find a constant that can be used to determine the number of triangles produced and the amount of area the triangles use on any stage. In Sierpinski's Triangle the group counted how many triangles were shaded in the first stage, in which the amount was three. As the group went through each stage they found the number of triangle was increasing by multiples of three, that is determined by using the stage number as a power of the constant three. As the number of shaded triangles increased the area of shade in the image decreased.

As the group found that shaded area was decreasing because of the increase of shaded triangles, we found that for every triangle there were three midpoints. For example, in the first stage of the Sierpinski Triangle, a central triangle was formed from the midpoints of the shaded original triangle. The group observed that for every one triangle the area would decrease by three-fourths its original shaded area. Therefore by using the stage number as powers to the three-fourths constant we were able to determine the decrease in shaded area for any stage. We also found that if the shaded area decreases without bound that non-shaded area will increase and cause the shaded area to disappear. The vertices of the triangle generated at any stage in these activities identify points that remain parts of the final fractal.

Tree Fractal

As we all know when trees grow they branch out. The process goes from large branches grow smaller ones and from them grow ever smaller branches. In the construction of the fractal tree, the group used 60 degree angles to determine where the placement of the next branch would occur from the trunk. At each new endpoint we would draw a new branch one-half the size of the previous branch at 60 degrees. As we completed the diagram we found that that every new branch was a smaller copy of the previous branch drawing magnified.

The group also noticed that the length of each new branch was a fraction of the length of the previous branch. This means that the original branch's length equals one, the next branch is one-half, and the branch derived after that is one-fourth of the original branch and so on to infinity. To obtain the next branch we had to take one-half of the previous branch; the new branch formed also has its length measurement. The interesting factor in this design is that the image does not cancel its self out during its approach to infinity as the shaded triangles of the Sierpinski's Triangle. The tree fractal just continues to grow in the number of branches. The new branches of the smaller fractions would probably be too small for the human eye to see but as long as the fractions can be reduced the tree still is producing new branches.

The completed tree, is in its limiting state, has some very intriguing visual properties. Each segment can be viewed as the trunk of its own tree, boxed in its own smaller hexagonal boundary. Look for these successively smaller but complete trees are exact images of the initial tree. All trees of all sizes in the figure have the same number of branches. Also the complete tree have intriguing visual properties. In particular, the spirals, always turning clockwise or counterclockwise, have lengths tied to geometric series. Their numbers are also tied to geometric series.

Four branches start at the first branching point, eight from the second branching points and so on.

Summary

The Tree fractal and Sierpinski's Triangle are two most important examples of deterministic fractals. The fractals give us a graphical representation of a mathematical equation or constant. Fractals helps us to visualize what a mathematical function produces graphically. It also helps in predicting length and distances in objects before performing any mathematical function or equation. Through fractals much research and time can be saved by designing an image that represents a complex mathematical equation or function. In the next discussion, another example of self-similar figures using a constant within a fractal called Square Carpet.

Fractals

A fractal is an object or quantity that displays Self-Similarity. This refers to parts of a figure which contain small replicas of the whole. It is created through several iterations and deals with shapes of infinite detail. They can be described as a graphical representation of an equation. Each branch or portion is exactly the same as the next. Fractals can be used to explain natural phenomenon and the dynamic behaviors in mathematics. An example is the veins in the body. They begin large at the heart and branch smaller and smaller until they are tiny capillaries in our fingers. The overall pattern is the same. Some examples of Fractals are the Sierpinski-Triangle, the Tree Fractal, Pascal's Triangle and the Square Carpet.

History

Although a fractal's roots can be traced back to Ancient Greece with spheres and cones, the first real fractals were discovered by a French mathematician Gaston Julia(1893-1978). He is known as one of the forefathers of the modern dynamical systems theory. At the age of 25, he published his 199 page masterpiece, which was full of classical fractals. He is known for the fractals, the "Julia Sets" most beautiful fractals today. They are important for the understanding of iterations of polynomials. Benoit B. Mandelbrot later developed the Mandlebrot set, which is the most famous of the fractals. He is largely

responsible for the present interest in Fractal Geometry. In 1945, Mandelbrot was introduced to Julia's 1918 masterpiece by his uncle. He did not like it because he could not relate to the style of mathematics used in the paper. Therefore, he chose a different course and with the aid of computer graphics he was able to show Julia's work as the source of the most beautiful fractals "Mandlebrot Set", known today. Mandelbrot was the first to state that the fractals could not be measured in whole-number dimensions but in an exponential dimension. One of his great discoveries was that nature tends toward fractals. He found that if you measure things such as clouds, coastlines, or even mountain ranges to the nearest irregularity, it would tends toward infinity.

Square Carpet

The Square Carpet is a fractal created by the great Polish mathematician Waclaw Sierpinski(1882-1969). One begins with a square in plane and connect the trisection points on the sides. Then the square is subdivided into eight little congruent squares of which the center one is dropped. At each stage, each square is transformed into eight new subsquares with the sides one-third as long. This is repeated for several iteration until the area decreases. While the area becomes smaller, the number of squares is increasing. The stages of the number of squares can be represented by the following table:

Stage	0	1	2	3	4	...	n
Number	1	8	64	512	4096		8^n(to the power n)

The stages of the area of squares can be represented by:

Stage	0	1	2	3	4	...	n
Area	1	8/9	64/81	512/729	4096/6561		(8/9)^n

The final result generates by infinitely several iterations, the Square Carpet. This is a fractal.

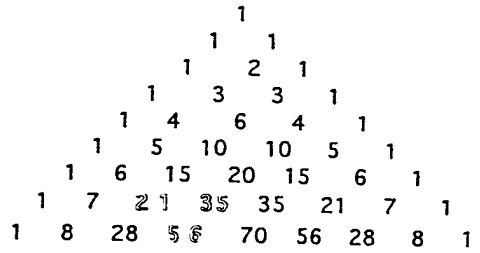
Pascal's Triangle

Pascal's triangle is commonly seen as a triangle array or numerical coefficients in the binomial expansion $(x + y)^n$ where the exponent increases the whole numbers from zero to n. This triangle array of numbers offers a rich setting for studying both numerical and geometric patterns.

$$(x + y)^0 = 1$$
$$(x + y)^1 = 1 \cdot x + 1 \cdot y$$
$$(x + y)^2 = 1 \cdot x^2 + 2 \cdot xy + 1 \cdot y^2$$
$$(x + y)^3 = 1 \cdot x^3 + 3x^2y + 3xy^2 + 1 \cdot y^3$$

For example, take the number 56 ,third in the bottom row(see diagram below). It is the sum of the two numbers 21 and 35 immediately above it.

Unfortunately, the numbers embedded deeply within the triangle are very large, and this ultimately the numerical iteration process increasingly laborious. Instead, we can introduce a coloring procedure into Pascal triangle that does not depends upon the magnitude of the number but only upon knowing which entries in the table are even and which are odd.



Modulo Arithmetic 2

The addition of even and odd numbers found in Pascals Triangle leads to modulo 2 arithmetic. In modulo 2 arithmetic, you are only concerned with the remainders after division by 2.

For example,

$$9+2=11 \qquad 8+4=12$$

The sum 11 has a "1" remainder in modulo 2 arithmetic and the sum 12 has a "0" remainder

$$9+2=1 \text{ modulo } 2 \qquad 8+4=0 \text{ modulo } 2$$

Being that the only remainder by division 2 are zero and one, every sum modulo 2 is zero or one; thus, even or odd.

Modulo Arithmetic 2: Coloring

If 2 cells directly above are different colors, then shade in the cell (this implies the cell have a value of one), else, leave the cell unshaded(giving it a zero value). End cells in each row are shaded. In worksheet 1.9A, we find that as the triangle increases to the nth stage, the number of rows are 2^n.

Coloring Shortcut

Next, we discovered a coloring shortcut using a process that required a binary coding of each location. In this method, the x-axis is diagonal to the left, and the y-axis is diagonal to the right (see worksheet 1.10A). Binary coding is the translating of regular numbers into a zero and one code. Our method was to express the binary number by using its sum components in terms of powers of two.

For example, the sum of number 3 expressed, in descending order, in powers of 2 is:

$$2^1 + 2^0$$

This means it takes a quantity of (1) power of 2^1 and (1) power of 2^0, thus the binary number is 11.

Another example is the number 6:

$$(1)2^2 + (1)\ 2^1 + (0)2^0$$

It takes a quantity of (1) power of 2^2 and (1) power of 2^1.
However, It does not require a value of 1 or 2^0, thus the binary number is 110.

In determining the color code, you pair up the (x,y) binary number as if you were taking the sum, then if two 1's appear above each other, then the cell is left white, otherwise, it is shaded. So the cell (6,3) or (0110, 0011), would be left white because two 1's appear above each other.

0110
0011

Comparing binary digits in this fashion is equivalent to performing a logical expression where both of the two conditions must be true for the conclusion to be true.

True	and	True	---->	True	1	and	1	---->	1
True	and	False	---->	False	1	and	0	---->	0
False	and	True	---->	False	0	and	1	---->	0
False	and	False	---->	False	0	and	0	---->	0

Modulo Arithmetic 3 and Modulo Arithmetic 9

In exercise 1.11A, we learn a modified coloring system based on modulo 3 arithmetic. We apply this to entries in Pascal's triangle. As expected, the only remainders in modulo 3 arithmetic (0,1,2) are of importance.

The color rule is: if the entry is 1 or 2 , shade the cell, if it is zero, leave the cell unshaded.

A more interesting approach, modulo 9 arithmetic involves remainders of 0,1,2,3,4,5,6,7, and 8. However, the color rule is simply: if the entry is zero, shade the cell, else, leave it white.

1.9 PASCAL'S TRIANGLE

1.9A

This activity centers around the famous array of numbers called Pascal's triangle. These numbers have been used to solve various probability problems. The connection here is to the Sierpinski triangle and fractals.

The first number in the initial row 0 of Pascal's triangle is 1. Every number thereafter is the sum of the two numbers immediately above it. If only one number occurs in the preceding row, assume the other to be 0. The triangle is completed through row 10.

1. How many numbers are in row 8? Row 9? Row 10? How many will be in row n?

2. Enter the numbers needed for rows 11 and 12. Can the numbers be extended? Can the numbers in row n be used to generate those in row $n+1$?

3. Start with the 1 in row 0 and imagine a vertical line down through the array. . Look at the numbers on opposite sides of the line in each row. What do you observe?

4. In rows 13, 14, and 15, enter only the letters E for *even* or O for *odd*. Do not compute the numerical values but rather use these relationships:

E + E = E E + O = O O + E = O O + O = E

Row	
0	1
1	1 1
2	1 2 1
3	1 3 3 1
4	1 4 6 4 1
5	1 5 10 10 5 1
6	1 6 15 20 15 6 1
7	1 7 21 35 35 21 7 1
8	1 8 28 56 70 56 28 8 1
9	1 9 36 84 126 126 84 36 9 1
10	1 10 45 120 210 252 210 120 45 10 1
11	1 11 55 165 330 462 462 330 165 55 11 1
12	1 12 66 220 495 792 924 792 495 220 66 12 1
13	O O E E O O E E O O E E O O
14	O E O E O E O E O E O E O E O
15	O O O O O O O O O O O O O O O O

1.9B

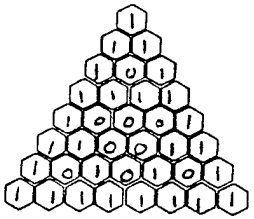
The addition of even and odd numbers leads to modulo 2 arithmetic. In modulo 2 arithmetic, only the remainders after division by 2 are relevant. For example, consider $5 + 7 = 12$ and $5 + 8 = 13$. The sum 12 has a 0 remainder and the sum 13 has a 1 remainder modulo 2.

$5 + 7 = 0 \mod 2$ $5 + 8 = 1 \mod 2$

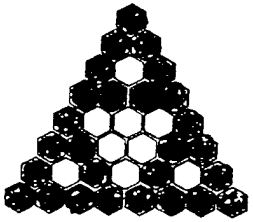
Since the only possible remainders on division by 2 are 0 and 1, every sum modulo 2 must be either 0 or 1. This is equivalent to saying every sum must be even or odd.

E + E = E	$0 + 0 = 0 \mod 2$
E + O = O	$0 + 1 = 1 \mod 2$
O + E = O	$1 + 0 = 1 \mod 2$
O + O = E	$1 + 1 = 0 \mod 2$

5. Enter 0 or 1 in the first eight rows of Pascal's triangle by writing a 0 if the table entry is even and 1 if it is odd.



6. This time color in the first eight rows of Pascal's triangle by shading in the entries with 1's (odds) and leaving unshaded the entries with 0's (evens).



7. Additional rows in the triangle can be colored by the same process using 0's and 1's or evens and odds. Study the coloring in the triangle above and give a rule for coloring each cell based upon the coloring of the two cells immediately above it.

1.10 SIERPINSKI TRIANGLE REVISITED

1.10A

The rule for coloring the cells in Pascal's triangle can be stated this way:
If the two cells directly above are different in color, then shade in the cell so the color is black. If they are the same in color, leave the cell unshaded so the color is white. End cells in each row are always colored black.

The first eight rows of the triangular array below have been colored using this rule.

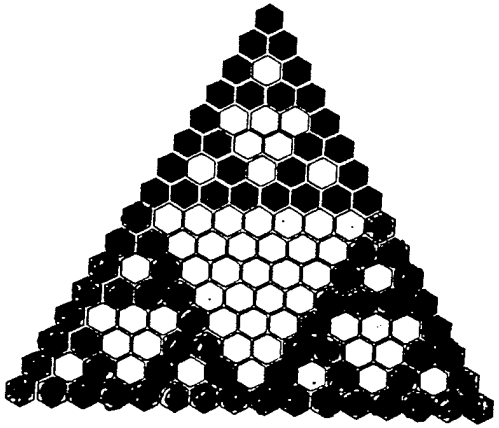
1. Do you see a geometric pattern in the first four rows of the display? How is it related to stage 1 in the construction of the Sierpinski triangle?

2. How are the first eight rows related to the first four rows? How are they related to stage 2 of the Sierpinski triangle?

3. Follow the rule above and color in the next eight rows on the triangle. What stage of the Sierpinski triangle appears from the completed figure?

4. How many rows would be needed in all to represent stage 4 of the Sierpinski triangle? stage 5?

STAGE	1	2	3	4	5	...	n
NUMBER OF ROWS	2	4	8				



5. Now generalize the results in the table. How many rows are needed for stage n ?

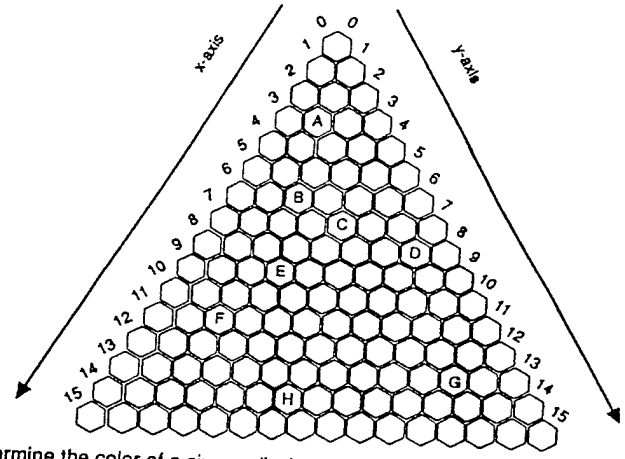
A COLORING SHORTCUT

1.10B

The question arises as to whether or not there is a direct way of finding the coloring of any given cell in Pascal's triangle without running the process through all rows above it. The answers is yes, but the process requires a binary coding of each location.

Start with the origin (0 , 0) as the top entry in the triangular array. Let the x -axis be diagonal to the left and the y -axis diagonal to the right. Then each pair of coordinates (x , y) corresponds to a specific location in the array. Cell A has coordinates (2,1).

1. Give the coordinates for cells B, C, and D.



To determine the color of a given cell, place the binary expansions of the two coordinates of the cell above each other and follow this rule:
If two 1's appear above each other in any one of the columns, then the cell is left white. Otherwise, it is shaded in as black.

2. The 4-digit binary coordinates for cell E are (0110,0011). When placed above each other, do any columns have two 1's? Will the cell be colored black or white?

3. What is the color of cell F? of cell G? of cell H?

Convert these coordinates to binary form. Then determine if the corresponding cells are colored black or white.

4. (7 , 9)

5. (12 , 16)

6. (25 , 40)

1.11 NEW COLORING RULES AND PATTERNS 1.11A

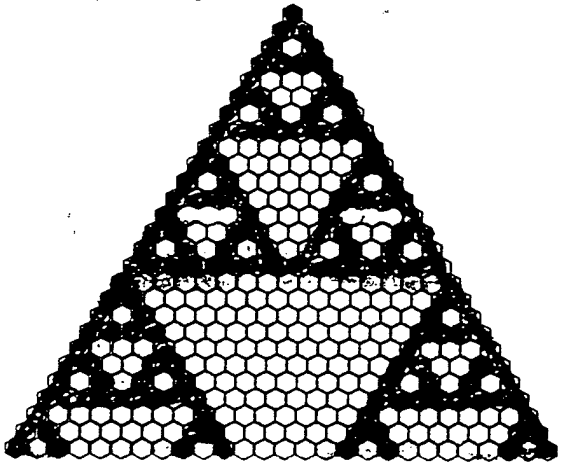
In this enrichment activity, a modified coloring system is applied to entries in Pascal's triangle based on modulo 3 arithmetic. A new, but predictable, pattern emerges in the coloring of the cells.

In modulo 3 arithmetic, only the remainders after division by 3 are of interest. As an example, consider 5 + 7 = 12, 5 + 8 = 13, and 5 + 9 = 14. The sum 12 has a 0 remainder, the sum 13 has a 1 remainder, and the sum 14 has a 2 remainder.

$5 + 7 = 0 \mod 3$ $5 + 8 = 1 \mod 3$ $5 + 9 = 2 \mod 3$

Since the only possible remainders upon division by 3 are 0, 1, and 2, *every* sum modulo 3 must be 0, 1, or 2.

1. Refer to the numerical entries in rows 0 through 8 of Pascal's triangle. Express each number in modulo 3 form and then color in the corresponding cell using the following rule:
   If the entry is 1 or 2, shade the cell black. If the entry is 0, leave the cell unshaded as white.
2. Study the coloring on the cells thus far completed. How does it compare with stage 1 of the Sierpinski triangle variation on Activity sheet 1.1B?
3. Try coloring in the remaining rows by replicating the pattern that you see in the first nine rows. The pattern that emerges should contain the 18 small triangles found in stage 2 of the Sierpinski triangle variation mentioned above.



1.11B

In modulo 9 arithmetic, only the remainders after division by 9 are of interest.

$5 + 11 = 7 \mod 9$ $5 + 12 = 8 \mod 9$ $5 + 13 = 0 \mod 9$

Since the only possible remainders upon division by 9 are 0, 1, 2, 3, 4, 5, 6, 7, and 8, every sum modulo 9 must be one of these numbers. This next activity requires finding the numbers in Pascal's triangle that are divisible by 9 with remainder 0. These are the numbers equal to 0 mod 9.

4. Refer to the numbers in Pascal's triangle and their mod 9 form. Color the corresponding cells in this array using the following rule:
   If the entry mod 9 is 0, shade the cell black.
   Otherwise, leave the cell unshaded as white.

See how quickly you can see a coloring pattern emerge that you can follow to complete the array.